PLANT PATHOLOGY

A RECORD OF CURRENT WORK ON PLANT DISEASES AND PESTS

Published quarterly for the
Ministry of Agriculture, Fisheries and Food
Plant Pathology Laboratory
Harpenden, Herts

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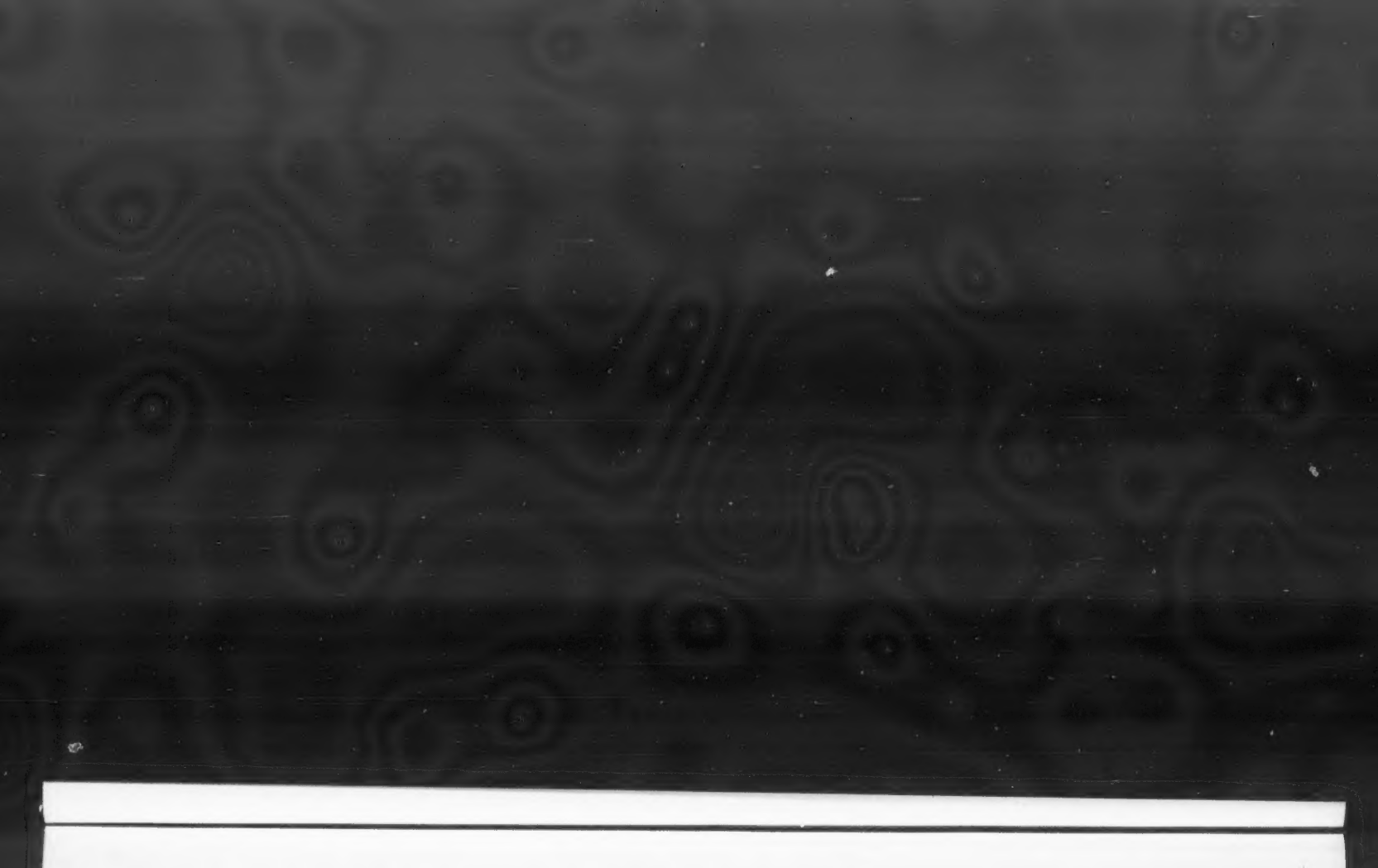

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A COMPARISON OF VARIOUS CHEMICALS FOR CONTROL OF THE BLACK CURRANT GALL MITE

by C. A. COLLINGWOOD

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LIME sulphur, first shown to be effective against the black currant gall mite, *Phytoptus ribis* Nal., by Lees (1920), did not come into general use until Hatton, Amos and Tydeman (1925) demonstrated that improved control could be obtained by spraying at the grape stage of bud development. The concentration of 8·5 per cent, used in early trials, greatly reduced infestations but failed to prevent a gradual annual increase in the number of big buds occurring on the sprayed bushes. At the same time it was accompanied by a certain amount of leaf scorch which was accentuated as varieties more sensitive to sulphur were introduced. This led Jary, Austin and Pitcher (1938) to undertake a more critical assessment of the effect of lower concentrations of lime sulphur. By applying 8·5, 3·3, 1·7 and 1·0 per cent to heavily infested bushes these workers showed that, in the first year, the degree of control was directly related to the concentration but, after two years applications, the resulting infestations did not differ significantly. Subsequently, 4 per cent was recommended for use on the more tolerant varieties and 2 per cent on sulphur-sensitive ones but, in an effort to minimize phytotoxicity, it became a fairly general practice for growers to use only the lower concentration.

Experience during recent years has shown that heavy infestations of gall mite often developed in plantations of quite moderate age, even when lime sulphur was used regularly. Since Ahlberg (1951), working in Sweden, failed to achieve very satisfactory control with ten applications of 2 per cent lime sulphur it seemed that this material was of doubtful value when used at concentrations which avoided excessive leaf scorch. It is against this background that trials were started during 1956 in both the East Midlands and Kent to test a range of recently introduced chemicals. Concurrently with field screening trials there have been more detailed experiments to evaluate the potentialities of endrin, which showed promise at an early stage, together with a further investigation into the acaricidal efficiency of lime sulphur.

METHODS AND MATERIALS

Layout of trials. In the East Midlands all trials were carried out on mature bushes, while in Kent most of the experiments were conducted on plants, not more than three years old, grown from infested cuttings. The plot size and replication varied and will be referred to in more detail under the separate experiments. The variety, Wellington XXX, used exclusively in Kent, was also most commonly used in the East Midlands.

Spraying equipment. Applications were made by both pressurized knapsack and power sprayer in the East Midlands. In Kent a low pressure hand sprayer was used for the plots of young bushes, and a power sprayer for the mature ones; 100 per cent lime sulphur was atomized from a paint gun attached to a motor driven compressor. All high volume sprays were applied with the object of thoroughly wetting all parts of the bushes.

Times of application. In the past, lime sulphur has normally been applied at the grape stage, i.e., when the blossom buds appeared as a tight cluster at the base of the rosette leaves. Recent observations (Collingwood and Brock, 1959), however, showed that very few mites emerged from overwintered, infested buds until the blossoms began to open. Peak emergence occurred during the blossom period, and mites continued to emerge at a reduced rate for some weeks after. In addition, there was evidence that the earliest axillary buds had not developed sufficiently to provide protection for the invading mites until the blossom was fully open.

As a result of this information, sprays were applied in the Kent trials with the object of obtaining the maximum mortality of exposed mites before axillary bud development provided protection but avoiding, as far as possible, damage to pollinating insects. Applications were made immediately before the blossom period; when about 50 per cent of the fruit had set, and at the end of the blossom period. In the East Midlands, sprays were applied at regular intervals during the dispersal period. The dates when the various stages of bud development occurred varied annually between the two areas and, to a lesser extent, between sites in each area.

Chemicals. Wherever possible the spray chemicals are listed under their common names, but for some of the newer materials it has been necessary to use a registered trade name. With the exception of benzyl benzoate, commercial formulations were used; aldrin, chlorobenzilate, demeton-methyl, diazinon, dieldrin, endrin, lindane, malathion, parathion, phenkapton, rotenone and schradan being in the form of emulsifiable concentrates (E.C.) and chlorbenside as a wettable powder (W.P.). Other materials were:

Benzyl benzoate: a laboratory preparation (E.C.).
Chlorthion: *O*, *O*-dimethyl *O*-(3-chloro-4-nitrophenyl) thiophosphate (E.C.).
Delnav: 1, 4-dioxan-2, 3-diyl bis diethyl phosphorothiolothionate (E.C.).
Dipterex: dimethyl (2, 2, 2-trichloro-1-hydroxyethyl) phosphonate (E.C.).
Fluoroacetamide: an aqueous solution.
Isolan: 1-isopropyl-3-methylpyrazolyl-(5)-dimethylcarbamate (E.C.).
Lime sulphur: containing approximately 24 per cent w/v polysulphide sulphur.
Karathane: 2-(1-methyl-*n*-heptyl)-4, 6-dinitrophenyl crotonate (W.P.).
Kelthane: 2, 2, 2-trichloro-1, 1-di-(*p*-chlorophenyl) ethanol (E.C.).
Petroleum oil: an E.C. containing approximately 60 per cent w/w neutral oil, of which 80 per cent distils between 380–400°C and which contains not less than 92 per cent unsulphonated residue.
Phosdrin: 2-methoxycarbonyl-1-methylvinyl-dimethyl phosphate as an aqueous solution.
Rogor: *O*, *O*-dimethyl *S*-(*N*-methylcarbamoylmethyl) phosphorothiolothionate (E.C.).
Sevin: *O*-1-naphthyl *N*-methylcarbamate (W.P.).
Thiodan: 8, 9, 10, 11, 12, 12-hexachloro-3, 5, dioxa-4-thiatricyclo-[5, 4, 1 ^{6,11}] dodec-9-ene 4-oxide (E.C.).
Wettable sulphur: containing approximately 70 per cent w/w sulphur.

The concentrations listed in the tables refer to the amounts of active ingredients in the dilute sprays, except in the cases of lime sulphur, petroleum oil and wettable sulphur. To all sprays used in Kent, except those containing sulphur and petroleum oil, 0·02 per cent of the surfactant, dioctyl sodium sulphosuccinate, was added, and was similarly used in 1957–58 in the East Midlands trials.

Assessment of results. Infestations were assessed after the leaves had fallen in the autumn. On mature bushes all healthy and infested buds were counted on a sample of not less than twenty shoots, each two feet in length, per plot; on young bushes all buds were counted. From these figures the percentage of infested buds was calculated.

SCREENING TRIALS

Initially, the materials used were chosen as representatives of the main groups of chemicals already reported as possessing acaricidal properties; others were introduced into subsequent trials as chemicals or plant material for testing became available.

TABLE 1

Screening Trials, 1956–58

Treatment		Infested Buds
Chemical	*per cent*	*Mean per cent*
EAST MIDLANDS, 1956		
Sprayed April 20 and May 11		
Chlorobenzilate	0·04	4
Chlorthion	0·1	8
Demeton-methyl	0·05	7
Diazinon	0·04	7
Endrin	0·04	2
Parathion	0·04	9
Wettable sulphur	0·4	5
Untreated	—	8
Sprayed April 20, May 11 and June 1		
Chlorobenzilate	0·04	5
Endrin	0·04	<1
Wettable sulphur	0·4	3
Untreated	—	10
EAST MIDLANDS, 1957		
Sprayed April 17		
Endrin	0·04	2
Fluoroacetamide	0·02	5
Isolan	0·04	6
Kelthane	0·04	6
Phenkapton	0·04	3
Untreated	—	9
EAST MIDLANDS, 1958		
Sprayed May 12 and May 26		
Delnav	0·04	48
Endrin	0·04	1
Fluoroacetamide	0·1	1
Kelthane	0·04	40
Lime sulphur	1·0	22
Phenkapton	0·04	30
Thiodan	0·04	3
Wettable sulphur	0·4	18
Untreated	—	45

Treatment		Infested Buds
Chemical	*per cent*	*Mean per cent*
KENT, 1956		
Sprayed May 4 and May 24		
Benzyl benzoate	0·03	19
Chlorbenside	0·05	26
Chlorobenzilate	0·05	21
Demeton-methyl	0·1	32
Diazinon	0·05	13
Endrin	0·05	0
Karathane	0·03	14
Lime sulphur	2·0	5
Malathion	0·1	28
Petroleum oil	2·0	6
Rotenone	0·01	11
Untreated	—	27
KENT, 1957		
Sprayed May 3 and May 20		
Aldrin	0·1	23
Dieldrin	0·05	20
Kelthane	0·1	40
Sprayed April 30 and May 20		
Endrin	0·05	0
Sprayed April 6		
Lime sulphur	100·0	43
Untreated	—	55
KENT, 1958		
Sprayed May 14 and May 28		
Delnav	0·06	43
Endrin	0·04	1
Rogor	0·04	35
Sevin	0·1	17
Untreated	—	27

In the East Midlands, all sprays were applied by a pressurized knapsack sprayer to plots containing between four and forty bushes replicated two to four times. In Kent, duplicate plots of six young bushes were used in 1956–57 and sprayed by a low pressure hand machine; in 1958 unreplicated plots of nine mature bushes were sprayed by a power machine.

From Table 1 it will be seen that endrin proved superior to the other materials in all three trials in 1956, and was especially effective when applied twice after the end of April. It maintained its efficiency in the two following years when included as a standard treatment. Lime sulphur and petroleum oil, used at 2 per cent in Kent in 1956, also reduced the infestation considerably, but neither had given satisfactory commercial control in previous years.

Of the materials tested in the East Midlands in 1957, both fluoroacetamide and phenkapton were considered worthy of further trial. The latter was discarded following its poor performance in 1958, but the former gave results comparable to endrin, as did Thiodan which was tested for the first time.

In supplementary laboratory tests it was found that Dipterex, lindane, Phosdrin and schradan exhibited only slight residual toxicity to mites emerging from infested buds, and 0·1 per cent endrin had no effect when shoots containing infested buds were dipped during the dormant season.

From the above results it is clear that the level of field performance of individual chemicals against the black currant gall mite is a markedly specific attribute, and biological efficiency varies greatly, even between very closely related materials. This was most clearly shown by the comparison made in Kent in 1957 between endrin and two of its analogues; whilst the former proved outstanding, neither aldrin nor dieldrin gave more than slight control.

TRIALS WITH ENDRIN

Effect of time of application. This was studied in detail in the East Midlands by applying single applications, at weekly intervals, from the grape stage until two or three weeks after the end of the blossom period. Trials of a similar pattern, though with greater intervals between sprays and including double applications, were also made in Kent. All sprays, to which 0·02 per cent dioctyl sodium sulphosuccinate was added, contained 0·04 per cent endrin, with the exception that 0·05 per cent was used in Kent in 1957.

TABLE 2

Efficiency of Endrin when Applied at Different Stages of Bud Development

Stage of Bud Development when Sprays Applied	Per cent Infested Buds				
	East Midlands		*Kent*		
	1957	*1958*	*1957*	*1958*	*1958*
A. Grape stage	29	18	—	—	—
B. First open flower	16	15	10	6	14
C. Full blossom	13	2	—	—	—
D. 40 per cent fruit set ..	10	2	1	1	3
E. 100 per cent fruit set ..	6	< 1	—	—	—
F. 7 days after 100 per cent set	10	2	—	—	1
G. 14 days after 100 per cent set	7	4	5	—	—
H. 21 days after 100 per cent set	30	—	—	—	—
B + D	—	—	—	< 1	2
D + F	—	—	—	—	1
D + G	—	—	0	—	—
Untreated	38	37	55	64	27
Concentration of endrin per cent	0·04	0·04	0·05	0·04	0·04
Method of application	Knapsack		Hand sprayer		Power

It will be seen from Table 2 that the degree of control obtained by a single application of endrin increased with successive sprays, until a maximum was reached at the end of the blossom period; it then decreased with still later applications. Under experimental conditions excellent control was obtained with a single spray applied at the best time; the Kent results also show that a consistent, but only very slight, improvement was achieved from two applications. It is also of interest to note that efficiency was quite independent of the type of machinery used; equally good results being obtained with a knapsack and a low pressure hand sprayer, as with a high pressure power machine.

Effect of varying the concentration of endrin. As previously mentioned (Table 2) a single spray, containing 0·04–0·05 per cent endrin applied at the best time, gave a very high degree of control. Information from two other trials, when sprays were also applied close to the best time, is summarized in Table 3. An experiment in the East Midlands showed an increase in control by raising the concentration from 0·01 to 0·02 per cent, but no obvious improvement was obtained with higher rates. In Kent, a small but consistent superiority of 0·05 over 0·025 per cent was maintained with two different times of application in one trial (Table 3), but not when it was duplicated at another site. There is thus a suggestion that 0·025 per cent is a marginal concentration which may occasionally give inferior results, but from Table 2 it is clear that consistently good results can be obtained with 0·04 per cent endrin.

TABLE 3

A Comparison of Different Concentrations of Endrin

East Midlands, 1957			Kent, 1957		
Endrin *per cent*	Date Sprayed	Infested Buds *Mean per cent*	Endrin *per cent*	Date Sprayed	Infested Buds *Mean per cent*
0·01	May 8	6	0·025	April 30	5
0·02	"	4	0·05	"	1
0·04	"	3	0·025	May 20	14
0·08	"	3	0·05	"	5
Nil	—	9	Nil	—	55

Effect of adjuvants on the efficiency of endrin sprays. Collingwood and Brock (1959) have already shown that emergence of mites from the overwintered buds is very protracted, starting just before the blossom opens and extending over a period of at least seven weeks. Studies of mite distribution on bushes during the period of emergence also indicated that, apart from those which could be found actively in process of dispersal on the foliage and shoots, there were only two sites where aggregations occurred. These were in the overwintered infested buds, and in the axils of leaves and in terminal buds of the current year's shoots. It thus appeared that, due to a behavioural factor or, perhaps, to an attractant associated with the meristematic tissue of rudimentary axillary buds, the emerged mites congregated at sites where buds would be formed.

From these observations it seemed possible that the efficiency of any chemical, applied before mites began to emerge from the overwintered buds, might be enhanced by the addition of a material which would increase the initial deposit, and improve the persistence on the exterior of infested buds. Similarly, for sprays applied after dispersal had begun, the addition of a surfactant might ensure a more thorough cover, especially in the axils of leaves where exposed mites were already present.

One possible means of improving the persistence of endrin, tested in Kent in 1958, was the addition of one per cent refined petroleum oil. As will be seen in Table 5, this was compared with a similar endrin spray to which was added 0·02 per cent of the surfactant, dioctyl sodium sulphosuccinate. Both were applied on April 22, just after the bud scales had been shed and when the earliest flowers were opening, and on May 15, when 40 per cent of the fruit had set. The performance of endrin-petroleum oil applied on April 22 was no better than the standard endrin-succinate treatment, and considerably inferior to it on May 15. Thus, any improvement in persistence, which petroleum oil may have conferred on the endrin deposit, was not reflected in a reduction in infestation. By visual assessment the endrin-petroleum oil spray applied on May 15, when much foliage was present, possessed inferior wetting properties compared with endrin-succinate, and this factor could account for the differing efficiency of these sprays.

In the East Midlands, partially hydrolyzed polyvinyl acetate, at the rate of 1 lb per 100 gal, and a proprietary resin emulsion, were added to sprays containing either lime sulphur or endrin which were applied before the blossom period. Results from six trials showed that, in all experiments, the control obtained by endrin or lime sulphur alone was of the same order as that from similar sprays containing the resin formulations.

Another comparison was made to assess the value of adding a surfactant to improve the wetting properties of endrin sprays applied near the best time. In two trials, the results of which are shown in Table 4, sprays derived from a commercial formulation, alone and with the addition of 0·02 per cent dioctyl sodium sulphosuccinate, were compared as single or double applications. On each occasion a higher degree of control was obtained by the spray containing additional surfactant.

TABLE 4

Effect on the Efficiency of Endrin Sprays of Adding a Surfactant

East Midlands, 1958			Kent, 1957		
Treatment *per cent*	Date Sprayed	Infested Buds *Mean per cent*	Treatment *per cent*	Date Sprayed	Infested Buds *Mean per cent*
Endrin 0·04	May 12, May 26	5	Endrin 0·05	May 1	5
Endrin 0·04 + Succinate 0·02	May 12, May 26	1	Endrin 0·05 + Succinate 0·02	May 1	1
Untreated	—	45	Endrin 0·05	May 1, May 21	1
			Endrin 0·05 + Succinate 0·02	May 1, May 21	0
			Untreated	—	54

The effect of endrin on mites in young axillary buds. Following a single application of 0·05 per cent endrin and 0·02 per cent dioctyl sodium sulphosuccinate on June 6, 1956, samples of the current year's shoots were taken on July 17, and the axillary buds examined for the presence of mites. Twenty-three per cent of the buds were infested, of which 15 per cent contained only dead mites, while the remaining 8 per cent had an average of three living mites per bud. On unsprayed bushes the infested buds averaged twenty-four living mites per

bud. Similar observations made three weeks after spraying on May 7, 1957, showed that, of 24 per cent infested buds, 14 and 10 per cent contained dead and living mites, respectively. Dead mites were not observed in buds on unsprayed bushes in either year.

From these figures it can be concluded that endrin was toxic to mites within young buds, and there is also an indication that fewer mites succeeded in colonizing individual buds on sprayed bushes. While living mites were usually found at the centres of developing buds, the position of dead mites depended on the interval between spraying and inspection. Groups were often found between the inner bud scales, suggesting that these had entered the buds before treatment, were killed by the spray, and subsequent bud development had continued normally; the site occupied by the dead mites representing the stage of bud development at the time of spraying.

Endrin residue on fruit at harvest. The results of analyses of ripe fruit from one of the Kent trials, and from others specifically designed to obtain information on harvest residues, have been kindly provided by Mr. R. P. Tew and Miss J. Sillibourne. These showed that a residue of 0·15 p.p.m. was obtained from fruit sprayed with 0·0375 per cent endrin and 0·025 per cent dioctyl sodium sulphosuccinate on April 23, 1958 (first open flower). For applications on May 14 (40 per cent fruit set) or May 28 the residue was of the order of 1–2 p.p.m. Since the fruit was picked on July 28 the latter residue had persisted for a period of at least two months. Further analyses showed that although endrin could be found in the pulp none was detectable in expressed juice, from which it was concluded that the deposit was probably associated with waxes on the skin of the fruit.

TRIALS WITH LIME SULPHUR AND WETTABLE SULPHUR

Applications of dilute sprays. Since, in recent years, lime sulphur had failed to give satisfactory control in commercial plantations when applied at the grape stage at concentrations up to 4 per cent, both this material and wettable sulphur were tested at other stages of bud development in the screening trials listed in Table 1.

In the East Midlands, 0·4 per cent wettable sulphur, applied in 1956 as double or triple applications on April 20 (grape stage), May 11 (full blossom) and June 1, effected some reduction in the infestation, but the results were far less satisfactory than those obtained with endrin in the same experiments. Similar results were obtained in 1958 with one per cent lime sulphur and 0·4 per cent wettable sulphur applied on May 12 (40 per cent fruit set) and May 26. Two per cent lime sulphur, applied in Kent in 1956 on May 4 (50 per cent fruit set) and May 24, was also markedly inferior to endrin.

These results indicated that, irrespective of the time of application, neither lime sulphur nor wettable sulphur were likely to prove really effective at the concentrations already used. As, however, there was doubt whether the use of endrin would be permitted, because of residues persisting in the fruit at harvest, one further trial was carried out in 1958 to test the efficacy of higher concentrations applied before the blossom period, as these had been reported to be effective by earlier workers.

The results, Table 5, show that for applications on March 27 (bud burst), April 8 (grape stage) and April 22 (first open flower) there was no improvement in control when the concentration was increased from 8 to 12 per cent; on the two later occasions 4 per cent was inferior to 8 per cent lime sulphur. Each concentration showed a correlation between time of application and level of

control achieved, the later applications being more effective, but even 12 per cent lime sulphur was inferior to the endrin-succinate spray when these were compared on April 22.

TABLE 5

Comparison of Lime Sulphur and Endrin, Kent, 1958

Treatment *per cent*	Per cent Infested Buds Following Sprays Applied on:				
	Mar. 27	*Apr. 8*	*Apr. 22*	*May 15*	*Apr. 22 May 15*
Lime sulphur 4	—	42	19	—	—
,, 8	39	20	13	—	—
,, 12	37	22	12	—	—
,, 100	—	—	27	—	—
Endrin 0·0375	—	—	6	6	—
Petroleum oil 1·0 ..					
Endrin 0·0375	—	—	6	1	<1
Succinate 0·02					
Untreated	64				

Complementary to the above trial, another replicated experiment was conducted on healthy, mature bushes of Wellington XXX to assess the phytotoxicity of 8 per cent lime sulphur applied by power sprayer on the same dates. The bud-burst spray (March 27) caused scorching to the apices of all exposed leaves, but had no effect on subsequent growth. Severe marginal scorching of all primary leaves occurred when 8 per cent lime sulphur was applied at the grape stage (April 8), whereas the spray applied at first blossom (April 22) caused only very slight yellowing near the tips of the lobes of occasional leaves which were unfolding at the time of spraying. At intervals, records were taken of blossom buds, flowers, fruit set and finally the crop at harvest time. There were no differences between treated or unsprayed bushes at any stage and, despite the severe phytotoxicity of the grape stage spray, this affected neither the size of fruit nor the yield at harvest, as Kirby and Bennett (1958) also found when using 2 per cent lime sulphur. Resulting from general observation over a period of many years there is a widely held theory that the phytotoxicity of lime sulphur is accentuated when sprays are applied during periods of low temperature. Such may be the explanation of the contrasting results obtained in 1958, as the maximum screen temperature reached only 47°F on April 8, when severe scorching occurred, compared with 59°F on April 22; on each occasion the wind was force 2 from the north-east.

Applications of lime sulphur as a concentrate. Studies by Moore (1957), who showed that finely atomized, concentrated lime sulphur could be less phytotoxic to apple than coarser, dilute sprays, led to this method also being tested. Undiluted lime sulphur applied in Kent (Table 1) on April 6, 1957, (first open flower) at about 6 gal/ac gave practically no control. A similar treatment at 12 gal/ac on April 22, 1958, (Table 5) also at the first flower stage, reduced the infestation by slightly more than one-half, but was less effective than dilute sprays of either lime sulphur or endrin applied at the same time. Since both the 4 per cent dilute spray and the concentrate application required approximately the same quantity of lime sulphur per acre, it would seem that, for a given dosage rate, the dilute spray is more effective. This may be due to differences in distribution of the deposit on the bushes or to differential persistence.

DISCUSSION

The traditional method of controlling black currant gall mite has been by the use of lime sulphur or, to a lesser extent, petroleum oil. Apart from its inclusion in one screening trial (Table 1), petroleum oil has not been used in the current experiments, but lime sulphur has received extensive study. Neither high concentrations, up to 12 per cent, applied before the blossom period (Table 5), nor double applications of one or two per cent at the end of the blossom period (Table 1), have given satisfactory control of heavy infestations. The pre-blossom use of an atomized concentrate, to reduce phytotoxicity, and of drenching sprays of 0·4 per cent wettable sulphur, have also proved ineffective. It would thus appear that sulphur, as used in these experiments, will not provide a satisfactory means of controlling this pest.

Only three other chemicals have shown promise of giving satisfactory control. Of these, endrin alone has been investigated in detail in this series of experiments, while the potentialities of fluoroacetamide and Thiodan are discussed by Collingwood, Vernon and Legowski (1960). Experiments with endrin have demonstrated that, while an application of 0·04 per cent just before the blossom period was more effective than lime sulphur (Table 5), the best time of application was at the end of the blossom period (Table 2), when even heavy infestations could be almost eradicated by a single spray.

Since few mites emerge from the overwintered buds before the blossom period, and emergence continues for several weeks (Collingwood and Brock, 1959), the efficiency of pre-blossom sprays will largely depend on the residual effect of the deposit. In this respect endrin was superior to lime sulphur, but attempts to increase persistence by the addition of petroleum oil, resin lacquer or partially hydrolyzed polyvinyl acetate were unsuccessful, the combined sprays giving no better control than endrin with additional surfactant. The use of petroleum oil after the blossom period (Table 5) even appeared to reduce efficiency.

Dense growth is present by the end of the blossom period, at which time some mites have already entered developing axillary buds on the young shoots, while others occur in the terminal buds and leaf axils. Thorough spraying of these sites is essential and there is evidence that the addition of a surfactant increased the efficiency of the spray. In addition, it has been shown that endrin possesses the valuable property of killing mites within the young buds, an action shared with fluoroacetamide and Thiodan, but lacking in lime sulphur. From the results of the 1957 trial in the East Midlands (Table 2), where a marked reduction in control was associated with the last application, it can be deduced that mortality to mites within axillary buds decreases rapidly as the buds develop. It has been shown that mites within mature buds are unharmed when these are dipped in 0·1 per cent.

Certain difficulties arise in translating these experimental results into commercial practice. For instance, in 1957, simultaneously with the experimental trials, similar sprays were applied on a commercial scale by a number of fruit-growers, all with disappointing results. From these it was inferred that success with endrin, even at the best time, depended on more thorough spraying than was usually practised. Some confirmation of this was obtained in the East Midlands in 1958, when attention to distribution of the spray resulted in better control.

Another aspect concerns the possible hazard to consumers which may result from the use of a persistent chemical of relatively high mammalian toxicity such as endrin. Amounts of residue recovered from the fruit at harvest time have already been quoted. From this, and similar information, official recommendations for safe use of endrin on black currants in Great Britain were issued in

1959*. These permit a spray at any time on nursery stock and non-fruiting bushes, but restrict the use on fruiting bushes to the pre-blossom period, unless the crop is under contract for juice extraction. With these restrictions endrin will not, therefore, provide a completely satisfactory means of control on fruiting bushes, but it can be used effectively on nursery stocks and young non-fruiting bushes in commercial plantations. Regular annual applications to such plants will, at least, ensure freedom from infestation up to the time bushes start cropping.

SUMMARY

Of twenty-eight chemicals tested against the black currant gall mite, mainly in field screening trials, only three have proved effective; 0·04 per cent endrin has given consistently good results over a period of three years, whilst in one trial 0·1 per cent fluoroacetamide and 0·04 per cent Thiodan gave results comparable to those obtained with endrin.

More detailed work with endrin has shown that the best time of application is at the end of the blossom period. In a series of trials the average percentage infested buds, following a single application at this time, has been two on the treated plots compared with forty-eight on the unsprayed. There was evidence to suggest that 0·025 per cent was a marginal concentration, whilst the addition of 0·02 per cent dioctyl sodium sulphosuccinate, as surfactant, improved the efficiency. The effectiveness of endrin sprays, applied before the blossom period, was not increased by the addition of petroleum oil, resin lacquer or partially hydrolyzed polyvinyl acetate.

High volume sprays, containing up to 12 per cent lime sulphur, applied immediately before the blossom period, have proved inferior to endrin applied at the same time, as also has an atomized spray of 100 per cent lime sulphur. Similar results have been obtained with double or triple applications of 2 per cent lime sulphur and 0·4 per cent wettable sulphur, when applications were made before and/or after the main blossom period. In one trial severe leaf scorch occurred when 8 per cent lime sulphur was applied at the grape stage, yet no reduction in yield could be detected.

The practical uses of endrin on commercial crops are discussed in relation to current recommendations designed to safeguard the consumer.

We wish to thank Miss A. M. Brock for help in recording the East Midlands trials, Mr. R. P. Tew and Miss J. Sillibourne for data on residues, and the many growers who provided facilities for spraying trials.

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* Copies of these recommendations are obtainable from the Ministry of Agriculture, Fisheries and Food, 5–8 St. Andrew's Place, London, N.W.1.

FURTHER EXPERIMENTAL WORK ON THE CONTROL OF *GLOEOSPORIUM* IN THE STORE

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IN experiments carried out in 1957, Cox's Orange Pippin fruits were subjected to the vapour of 2:4:5-(trichlorophenoxythio)trichloromethane. Some control of *Gloeosporium* rotting was obtained after a storage period of eighteen weeks, despite the fact that the apples had been artificially inoculated with a spore suspension of *G. perennans* to guarantee a high incidence of infection (Spencer and Wilkinson, *Nature, Lond.*, 1958, **181**, 1603–4). The inoculated fruits were placed in trays in single layers in units of nine, and enclosed in polythene tents measuring 5 × 2 × 2 feet. It was found that the best treatment was that in which the chemical, sufficient to give 0·1 g per cubic foot of air space in the tent, was applied to three one-bushel box liners fixed above the middle three trays of the tier.

More extensive studies with this chemical were carried out in 1958, when apples were again obtained from twenty-four-year-old trees on Malling IX rootstock, and during the experiment were kept at 37°F in a cold store. To make the maximum use of the limited storage space, each treatment, consisting of a unit of eight trays containing a total of between 253 and 270 fruits, was again housed in a polythene tent. The fruits in alternate trays had been dipped in a spore suspension of *G. perennans*; those in the intervening trays contained apples as picked from the orchard. The same amount of chemical as used in the 1957 trials (i.e., 0·1 g per cubic foot = 2 g per tent) was employed but, instead of being concentrated on liners between the middle three trays, it was distributed evenly in acetone solution over eight liners, one of which was stapled above each tray.

One tent with its eight trays was used for each of the following treatments:

1. Controls. Box liners received acetone only.
2. Box liners bearing the chemical, inserted after six weeks storage.
3. Box liners, bearing the chemical, removed after six weeks and replaced with freshly treated liners.
4. Treated liners removed after one week.
5. Treated liners removed after one month.
6. Treated liners removed after two months.
7. Treated liners left in position for the duration of the experiment, i.e., 4½ months.

Two additional tiers of trays, not enclosed in polythene tents, were placed in the store, and one only of these was supplied with treated liners.

At the end of eighteen weeks storage (February 4, 1959) nine of our colleagues each made an assessment of infection on the experimental fruits; this involved counting the total number of *Gloeosporium* lesions on each infected apple. The figures presented in the Table are the means of the nine separate assessments. Examination of these summarized results shows that where treatment did not begin until after six weeks of storage, there was no reduction of *Gloeosporium* rotting in the uninoculated apples. The corresponding apples which had been inoculated, however, showed a marked *increase* in infection. The probable

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Effect of Treatments with 2:4:5-(trichlorophenoxythio)trichloromethane on Gloeosporium *Rotting of Cox's Orange Pippin in Cold Storage*

Treatment	Inoculated*		Uninoculated	
	Percentage of Fruit with Lesions	*Lesions per Infected Fruit*	*Percentage of Fruit with Lesions*	*Lesions per Infected Fruit*
In polythene tents				
Control	87·0	7·6	50·2	4·6
Treated after 6 weeks storage ..	93·4	11·9	47·3	4·6
Liners replaced after 6 weeks ..	52·4	4·4	19·7	2·1
Treated 1 week	63·2	4·3	29·5	3·1
Treated 1 month	43·9	3·8	25·0	2·9
Treated 2 months	40·5	2·7	17·6	1·5
Treated 4½ months	37·4	2·4	11·8	1·6
Not in tents				
Control	49·8	3·0	17·5	1·8
Treated	35·4	1·6	16·4	2·4

* Fruits dipped in a suspension of the spores of *G. perennans* before treatment.

reason for this is that the infection process is well advanced after six weeks and it would appear, therefore, that if control is to be achieved, treatment should begin immediately the fruits are placed in storage.

Removal of the treated liners after six weeks storage and their replacement with liners freshly impregnated with the chemical, rather surprisingly, did not give as good a result as the full-time treatment. Since the replacement liners had no beneficial effect, opening the tent after six weeks had the effect of ending the treatment. Removal of the treated liners at various times throughout the experiment influenced the degree of *Gloeosporium* rotting observed. For example, 87 per cent of the inoculated controls developed lesions, whereas 63·2 per cent of those treated for one week did so, and of those treated for the length of the experiment only 37·4 per cent were affected.

The Cox's Orange Pippin used in these experiments were carrying a natural inoculum of *Gloeosporium* spp. which, at the end of storage, meant 50 per cent of those untreated (i.e., the uninoculated controls) being rejected as infected. Treatment with 2:4:5-(trichlorophenoxythio)trichloromethane at 0·1 g per cubic foot of the atmosphere for only one week reduced this figure to less than 30 per cent and, allowing the treated box liners to remain within the polythene tent for the length of the storage period, reduced the percentage of rejected fruits to less than twelve. It can be seen from the table that the numbers of lesions per fruit follow these general trends; thus, treatment for one or two months gave results intermediate between those for one week and 4½ months.

Though the chemical treatment did lead to a slight reduction of *Gloeosporium* attack in those trays of apples kept in the open store, this reduction was much less than was achieved in the tents. This perhaps is not surprising, since each of the treated box liners used carried only the same amount of chemical as each of those used in the tents. The vapour concentration which such a relatively small amount of material could maintain would clearly be much less in the open than under the tents. The greater incidence of infection of the fruits in the polythene tents, compared with that of apples in the open store, can be attributed to the high humidity prevailing in the tents.

From the evidence obtained in laboratory experiments and from results obtained in the past two seasons, the following conclusions may now be drawn. *Gloeosporium* rotting can be reduced by store fumigation, using 2:4:5-(trichlorophenoxythio)trichloromethane in the manner described. Comparison of the results of experiments carried out in 1957 and 1958 shows that the same quantity of this chemical, concentrated on three box liners and placed near to the apples, gave no better results than when it was distributed uniformly throughout the chamber. These results indicate that control of *Gloeosporium* can be obtained by a certain minimum atmospheric concentration of the fumigant. The fact that there was little or no control of *Gloeosporium* in those trays kept in the open store indicates that this minimum vapour concentration was not maintained under these conditions.

Whilst compounds other than 2:4:5-(trichlorophenoxythio)trichloromethane may also prove useful as volatile fungicides for this purpose, the problem of finding an effective method of application remains. The fixing of treated box liners to the underside of trays in which the apples are stored in a single layer only can never be seriously recommended for commercial practice, though some method of vaporizing the chemical into the atmosphere of the store might be practicable. From the present results it would appear that a satisfactory atmospheric concentration of 2:4:5-(trichlorophenoxythio)trichloromethane was maintained within polythene tents, but whether the same conditions can be reproduced in a commercial store remains to be investigated. Here it should be noted that the amount of chemical used in our experiments (0·1 g per cubic foot air space) was arbitrarily chosen. This amount gave promising results in certain previous work and, since it has been possible to study only a few factors at a time, this figure has remained unchanged. Whether, in fact, the vapour concentration obtained from this quantity of chemical at 37°F, is the best, is not known, but the absence of fruit damage and taint indicates that larger amounts might be tolerated. It is suggested that experiments in which varying quantities of the chemical are volatilized into the atmosphere of the fruit store, should be carried out. It may well be that fumigation with a high concentration for a short period will give adequate control, without causing fruit damage.

We have not studied the mammalian toxicity of this chemical, but we and our colleagues have eaten quantities of apples used in these experiments without ill-effects, and it is understood that toxicity trials are being carried out elsewhere.

SUMMARY

When 2:4:5-(trichlorophenoxythio)trichloromethane was used to treat the atmosphere in which Cox's Orange Pippin apples were stored, there was a marked reduction of the rotting caused by *Gloeosporium* spp.

POTATO BLIGHT EPIDEMICS

Throughout the World

The study of recent potato blight epidemics carried out at the Plant Pathology Laboratory, Harpenden, by A. E. Cox and E. C. Large with the help of collaborators in many parts of the world during the years 1955 to 1957, was published in January 1960 by the Agricultural Research Service of the U.S. Department of Agriculture, under the above title, as their Agricultural Handbook No. 174 (4to, iv+230 pages, with 93 maps and diagrams). The publication is obtainable from the Superintendent of Documents, Government Printing Office, Washington, 25, D.C.

DELAYED EMERGENCE OF THE PEA MIDGE

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BEVAN and Uncles (1958) collected data during their study of the soil population of the pea midge, *Contarinia pisi* (Winn.), that suggested approximately one-third of the 1956 overwintering larval population remained in the resting stage for a second winter. The possibility that such delayed emergence leads to unexpected outbreaks justifies accumulating all relevant data. It is difficult to obtain exact information about emergence dates and the larval-year of gall midges in the field, so the following facts, gained by keeping larvae in the Rothamsted Lodge insectary after completing their growth in the field, may be of interest.

Table 1 indicates that it is not exceptional for only some of a generation of this midge to emerge in one year, and for emergence to continue in the next. Seven of the nine samples of infested shoots and flowers collected in August 1957 produced midges in 1958, and all nine gave rise to midges in 1959. As to be expected from samples collected in August, no midges emerged the same year (1957) as the larvae were feeding. In contrast, five of the six samples collected in July 1959, about 4–7 weeks earlier but in a considerably warmer summer, produced midges later the same year.

TABLE 1

Dates of Emergence of C. pisi *in Rothamsted Lodge Insectary*

Sample		1958		1959	
		First	*Last*	*First*	*Last*
Harpenden 8.8.57 K. S. George		July 13	July 25	July 2	July 2
Crowle, nr. Doncaster*	i	—	—	June 9	July 20
15.8.57	ii	July 7	Aug. 1	June 10	July 18
J. M. Proctor	iii	—	—	July 12	Aug. 3
	iv	June 30	Aug. 15	June 24	July 29
	v	June 23	July 30	June 14	July 17
Wroot, N. Lindsey	i	July 1	Aug. 12	June 13	July 13
28.8.57	ii	July 8	July 30	June 14	July 7
R. Gair	iii	July 6	Aug. 4	June 20	July 13
Wentbridge, nr. Doncaster	i	—	—	July 27	Aug. 11
8.7.59	ii	—	—	July 27	Aug. 12
W. J. Bevan	iii	—	—	July 27	Aug. 24
	iv	—	—	July 31	Aug. 5
	v	—	—	—	—
	vi	—	—	Aug. 6	Aug. 14

* Mr. Bevan informs us that, although Crowle is actually in Lincolnshire, the general conditions for pea midge there are identical with those in the pea-growing area of Yorkshire.

Table 2 shows the numbers emerging in 1958 and 1959. The two Crowle samples that produced no midges in 1958 produced 126 and 148 respectively in 1959, and those that produced midges in 1958 produced almost 12, ¾ and 3½

times as many midges in 1959 as in 1958. Of the Wroot samples, one produced twice as many midges in 1959 as in 1958, one about the same number and the other considerably fewer.

It is interesting to speculate to what extent insectary-rearing at one place, e.g., Harpenden, of larvae fully fed in the field in other localities, portrays what happens in the field. The dates of the first emergences in 1958 and 1959 in the field and insectary corresponded rather closely. Bevan informed us (*in lit.*) that soil sampling in 1957 and 1958 indicated that 1956-infested fields gave well over half (almost two-thirds) the midges in 1957 and most of the remainder in 1958; after 1958 too few remained in those fields to make it worthwhile sampling from his (practical) point of view. However, very many of the fields infested in 1957 gave up most of their midges in 1958—some fields almost all—so there were not any 1957-fields worth sampling this year (1959). A more intensive joint study of field sampling and insectary rearing might show a closer parallelism than is suspected.

TABLE 2

Numbers of C. pisi *Emerging in Rothamsted Lodge Insectary*

Sample		1958			1959		
		♂	♀	*Total*	♂	♀	*Total*
Harpenden 8.8.57 (1 pod only)		7	0	7	1	0	1
Crowle, nr. Doncaster 15.8.57	i	0	0	—	59	67	126
	ii	11	5	16	72	112	184
	iii	0	0	—	43	105	148
	iv	42	47	89	17	45	62
	v	39	46	85	119	190	309
Wroot, N. Lindsey 28.8.57	i	26	60	86	24	47	71
	ii	10	13	23	15	37	52
	iii	38	85	123	26	31	57
Wentbridge, nr. Doncaster 8.7.59	i	—	—	—	17	18	35
	ii	—	—	—	23	32	55
	iii	—	—	—	37	39	76
	iv	—	—	—	2	2	4
	v	—	—	—	0	0	0
	vi	—	—	—	3	0	3

The duration of the period of emergence is noteworthy, but the peak is difficult to gauge on small numbers. A rather remarkable sudden increase in numbers, surpassing what seemed to be the peak, about June 25, 1959, took place in the thunderstorm spell about July 14 at Harpenden in the Crowle samples. Similar increased emergence of other species of gall midges has been observed in previous years.

Two breeding experiments were set up by one of us (M.K.A.) on July 9 and July 10, 1958. The filial generation emerged the following year, June 17 to July 24, and June 20 to July 16 respectively. One contained only males and the other five times as many males as females, indicating unisexual families. If this is later proved, *C. pisi* will be the third species of *Contarinia* in which this type of sexual generation occurs.

It is not known how many winters the fully-fed *C. pisi* larvae can remain in the soil, but it seems unlikely that this species can survive as long as *Sitodiplosis*

mosellana (Géhin). Some larvae of this species regularly spend 10–12 winters in the insectary before emergence. The record is eighteen winters: a larva extracted from wheat in late July 1941 did not emerge until June 23, 1959. Golightly (1952) demonstrated that considerable numbers of larvae in cocoons were still present in 1951 in a field that had not been cropped with wheat since 1944.

SUMMARY

More *C. pisi* that had completed their larval feeding in the field during 1957 emerged in the Rothamsted Lodge insectary in 1959 than in 1958. A sudden increase in number of emergences occurred in a thundery period in 1959. There are indications that unisexual families occur in the pea midge. The emergence of *S. mosellana*, one of the wheat blossom midges, after spending eighteen years as a fully-fed larva is noted.

We are indebted to Messrs. K. S. George, J. M. Proctor, R. Gair and W. J. Bevan for supplying us with samples of infested pea plants. We would like also to thank Mr. Bevan for constructive criticism of this paper.

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ADDITIONAL PEA VARIETIES AND NEW SELECTIONS RESISTANT TO FUSARIUM WILT

by E. W. Buxton
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During 1959 further experiments to find pea varieties that resisted wilt, caused by *Fusarium oxysporum* f. *pisi*, were done in the same way as those in 1958 and earlier (Buxton, Perry, Doling and Reynolds, *Plant Pathology*, 1959, **8**, 39–45). Two approaches to the problem were made: testing for wilt-resistance in progeny of healthy plants selected from varieties that wilted in 1958, and growing further pea varieties to determine their reactions to wilt. The experiments were at Yaxley, Peterborough, on wilt-infested land used for the 1958 experiments, and at Coggeshall, Essex, on a field that had carried severely wilted crops of peas, varieties British Lion and Clipper, in 1958.

RESISTANCE OF SELECTIONS FROM SUSCEPTIBLE VARIETIES

In the 1958 tests, isolated healthy plants appeared in twenty-two susceptible varieties. To test for their wilt-resistance, seeds from fifty-three of these apparently resistant plants were sown at Yaxley and Coggeshall in 1959. Table 1 gives the results of these tests.

TABLE 1

Wilt Reaction in Apparently Healthy Pea Selections from Varieties that Wilted in Tests made in 1958

Centre	Variety	Number of Plants Whose Seeds were Sown	Reaction to Wilt†	Trueness to Type of Wilt-resistant Progeny‡
Coggeshall	Delicatesse	1	R	T
	Gradus (early)	1	R	T
	Hurst's Stock 47/1	1	R	T
	Kelvedon Lion	2	R	T
	Lincoln	1	R	T
	Little Marvel	1	R	T
	Onward	1	VS	—
Yaxley	Alaska	1	R	T
	British Lion	1	R*	T
	Fertila	12	4R	T
			2R*	T
			3VS	—
			3VS*	—
	Hundredfold	4	VS	—
	Hurst's Stock 47/1	2	R	T
	Kelvedon Standby	1	R	NT
	Mansholt's Pluk	1	VS	—
	Partridge (susceptible)	1	R	T
	Pauli	1	VS	—
	Peter Pan	1	R	T
	Pioneer	3	1R*	NT
			2VS	—
	Roi des Conserves	2	R	T
	Rondo	3	1VS	—
			2VS*	—
	Tom Thumb	7	5R	T
			2R*	T
	Virtus	3	R	T
	Witham Wonder (tall)	2	R	NT

* Segregating.
† R = Resistant; VS = Very susceptible.
‡ T = True to type; NT = Not true to type.

Forty-nine per cent of the healthy plants selected in 1958 were in fact wilt-resistant. Observations on varietal characteristics were made and only three appeared to be not true to varietal type. Selection only, therefore, can quickly provide resistant stocks from important but susceptible varieties such as British Lion, Lincoln and Little Marvel (Plate I, 1).

WILT RESISTANCE OF VARIETIES

Thirty-five pea varieties were tested, thirteen at Yaxley, seventeen at Coggeshall, and five at both centres. They were sown on March 31 at Yaxley and on March 13 at Coggeshall; the replicated lay-out was similar to that described for the 1958 tests (Plate I, 2). The experiments were recorded by four independent observers on three occasions between June 17 and July 7 at Yaxley, and four times between June 10 and July 5 at Coggeshall. Twenty-three of the varieties were wilt-resistant, four were susceptible and eight very susceptible (Table 2). These results provide further varieties that could be used as parents to introduce resistance into susceptible popular varieties, which already have desirable characteristics.

TABLE 2

Wilt Reactions of Pea Varieties Grown in Infested Soil at Yaxley, Peterborough, and Coggeshall, Essex, in 1959

Very susceptible		
Aurora (H) (1) .. .. *C*	Foli (G) (1) .. .. *AM*	Miragreen (U) (1) .. *CF*
Diadem (2) .. F	Gladstone* .. .. A	Show Perfection (2) .. A
Douce Provence (2) .. *EAM*	Greenfeast (susceptible) (N) (2) *ACEFM*	
Susceptible		
Early Bird .. .. AM	Ridcovert (F) (1)** .. *CFM*	Viabona (F) (1) .. *C*
Early Gladstone** .. A		
Resistant		
Australian Dun (A) (2)** *S*	Heralda (G) (1) .. *C*	Pacific Freezer 3019 (U) (2) .. .. *F*
CB. 51–129 (H) (1) .. *X*	Kelvedon Triumph .. AM	Pacific Perfection (U) *CF*
Centurion (F) (1)** .. *AM*	Marathon Maple (2).. S	Perfection New Line (U) (1) .. .. *C*
Delice des Conserves (F) (1) .. .. EC	Midfreezer (U) (1) .. *F*	Perfection 326 (U) (1) *C*
Dun or Grey (2)* .. S	Minerva Maple (2)* .. S	Pygma (1) .. .. *C*
Eureka (U) (1) .. .. *C*	Onward E.1. (W.R.) (N) (2) .. .. *X*	Small Sieve Freezer (U) (1) .. .. .. *F*
Famous (U) (1) .. .. *C*	Onward E.2 (W.R.) (N) (2) .. .. *X*	Thomas Laxton (W.R.) (U) (1) .. .. ACFM
Freezer 321 (U) (2)* .. *F*	Onward E.3 (W.R.) (N) (2) .. .. *X*	

Country of origin of seed:	*Usage*	*In Britain*	*In country of origin*
(A) Australia	Amateur (gardens)	A	*A*
(F) France	Canning	C	*C*
(G) Germany	Exported as seed	E	*E*
(H) Holland	Freezing	F	*F*
(N) New Zealand	Market (sold in pod)	M	*M*
(U) U.S.A.	Stockfeeding	S	*S*
The remainder obtained in Britain	Not in commercial use	—	*X*

* = a few segregants seen.
** = marked tendency to segregate.

(1) = tested at Coggeshall only.
(2) = tested at Yaxley only.
The remainder at both sites.

An additional ten varieties from New Zealand, tested at Yaxley, had the same reactions to wilt as they did in 1958. Some other varieties that had already been tested were included again at both sites and, although most reacted as they did in 1958, a few anomalies were recorded:

Variety	Lincoln Small Blue	Lincoln	Fraser
Reaction in 1959 ..	Resistant* (Yaxley)	Resistant* (Coggeshall)	Susceptible† (Coggeshall)
Reaction in 1958 ..	Moderately susceptible (Yaxley)	Moderately susceptible (Yaxley) Very susceptible (Rayne)	Not tested
Reaction in 1957 ..	Not tested	Not tested	Resistant (Yaxley)

* Segregating, with a few plants susceptible.
† Reached full-podded stage before symptoms appeared.

SUMMARY

Of thirty-five further pea varieties tested at Yaxley, Peterborough and Coggeshall, Essex, for resistance to Fusarium wilt, twenty-three were resistant, four susceptible and eight very susceptible. Among peas grown from fifty-three apparently healthy plants selected from twenty-two different varieties that were wilt-susceptible in the previous year's tests, 49 per cent remained resistant when tested in 1959, and only three of the varieties were apparently not true to type. These selections may quickly provide a source of wilt-resistant stocks from important susceptible pea varieties.

We wish to acknowledge the assistance given in this work by Mr. L. J. Beaven, of Hurst and Son Ltd., Wholesale Seedsmen, London.

PEA VARIETIES RESISTANT TO FUSARIUM WILT

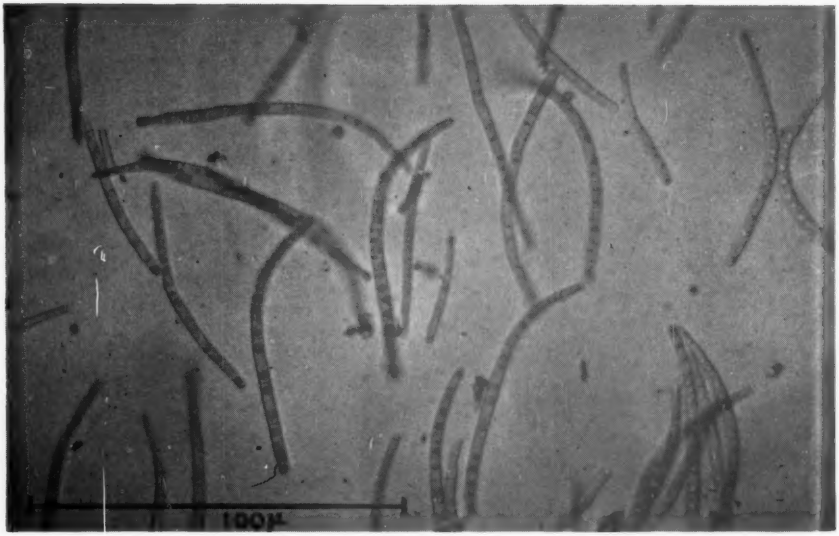
Photo: Rothamsted Experimental Station

1. Resistant and susceptible plants grown from seed of a susceptible variety that contained a few resistant plants in previous tests.

Photo: National Institute of Agricultural Botany

2. Resistant and susceptible varieties in a field trial at Yaxley, Peterborough, June 30, 1959.

PLATE I



1. *Above:* Typical spotting on upper leaf surface. 2. *Below:* Subhyaline multispetate conidia of the causal fungus, *Cercospora handelii.*

PLATE II

BUD PROLIFERATION IN POTATOES (see p. 75)

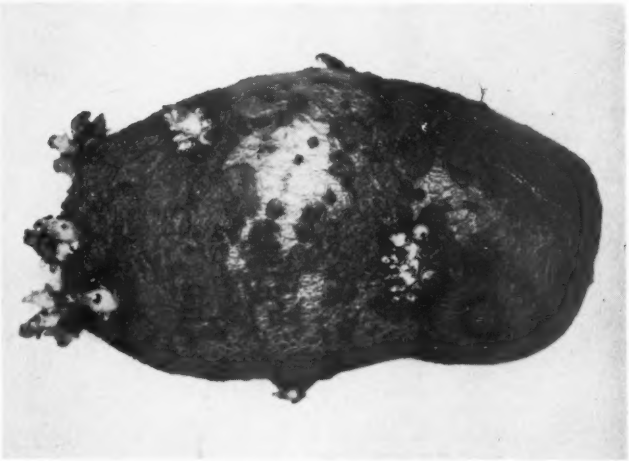


Photo: Ministry of Agriculture, Northern Ireland

1. Bud proliferation in association with common scab on a tuber of Golden Wonder.

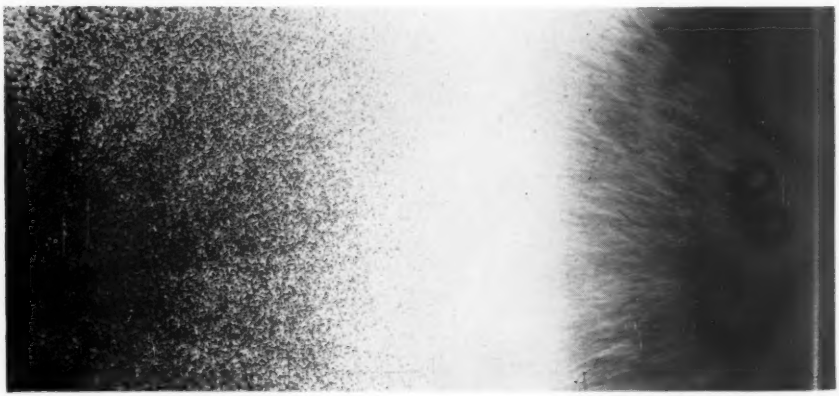
VIOLET ROOT ROT ON ALSTROEMERIA (see p. 76)

2. Discoloured and partly decayed root of *Alstræmeria aurantiaca* showing typical mycelial strands of *Helicobasidium purpureum*.

PLATE III

1. Stages in the development of microsclerotia of *Verticillium dahliae* (mounted in lacto-phenol) (× 600).

2. Darkly pigmented mycelium characteristic of *V. albo-atrum* (mounted in lacto-phenol) (× 600).



Photos: East Malling Research Station

3. Undersides of colonies of *V. dahliae* (*left*), and *V. albo-atrum* (*right*) (cleared with lacto-phenol) (× 2½).

PLATE IV

A CULTURE-MEDIUM AIDING THE IDENTIFICATION OF *VERTICILLIUM ALBO-ATRUM* AND *V. DAHLIAE*

by P. W. TALBOYS

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THE commonest pathogenic species of *Verticillium*, *V. albo-atrum* Reinke and Berth. and *V. dahliae* Kleb., can readily be isolated from diseased plant material by plating out excisions from the infected vascular tissues upon standard culture-media such as potato-dextrose, malt extract, prune extract or Czapek-Dox agars. However, difficulty is sometimes experienced in identifying the species with certainty because the distinctive mycelial characteristics fail to develop satisfactorily.

A medium which has been in regular use in this laboratory for about seven years appears to have overcome this difficulty; at no time during this period has there ever been any doubt as to the taxonomic identity of any of the numerous *Verticillium* isolates which have been obtained from a wide range of host plants.

The medium contains concentrated prune extract 100 ml, lactose 5 g, Difco yeast extract 1 g, agar 30 g, and distilled water to make up 1,000 ml. The pH of the medium is adjusted to 5·8–6·0.

> The concentrated prune extract is prepared by simmering 50 g chopped dried prunes with 1,000 ml water until they are soft; the mixture is then strained through muslin and the solution filtered and made up to 1,000 ml again with water. This extract may be sterilized in convenient quantities in plugged flasks and stored in a cold-room until required.

A standard 4-inch petri dish is normally poured with 20 ml of the medium, and the culture incubated at 22°C. Verticillate conidiophores of both species are usually apparent within 3–4 days.

Microsclerotia of *V. dahliae* begin to develop about five days after inoculation of the plate, and though they are not usually visible to the naked eye at this stage, the lateral budding of the hyphae can easily be seen under the microscope. With continued growth of the colony, the microsclerotia develop an intense black pigmentation, while most of the remaining mycelium remains hyaline (Plate IV, 1); this gives the underside of the colony a characteristic "gritty" appearance (Plate IV, 3). Generally the aerial mycelium of *V. dahliae* is rather profuse and fluffy, and conidiophores are relatively sparse.

Microsclerotia are absent from *V. albo-atrum*, but as the submerged mycelium ages the hyphal walls become darkly pigmented (Plate IV, 2), giving the older parts of the colony a greenish-black colour. This usually begins to develop about six days after inoculation, though it sometimes takes a few days longer. The darkening hyphae may become rather torulose, but there is no lateral budding of hyphae comparable with the early stages of microsclerotium formation in *V. dahliae*.

The macroscopic appearance of the underside of the *V. albo-atrum* colony is characteristically "fibrous" and quite distinct from the "gritty" appearance of *V. dahliae*, even to the naked eye (Plate IV, 3).

The aerial mycelium of *V. albo-atrum* is usually relatively sparse, but conidiophores are generally produced in very large numbers, and give the colony surface a grey "mealy" appearance.

Though mature colonies of *V. albo-atrum* and *V. dahliae* can generally be distinguished on the prune-lactose-yeast medium without microscopic examination, it is advisable to check the identification microscopically to avoid possible confusion with *V. tricorpus* Isaac, a much less common pathogen, which produces both dark mycelium *and* microsclerotia, together with chlamydospores, which are not formed by the other two species.

PARATHION RESIDUES ON EARLY POTATOES IN JERSEY

by D. R. A. DAVIES *and* D. A. TAME
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and G. E. THOMAS
States Experimental Station, Jersey

SYMPHYLIDS are common soil animals in the Channel Islands (Edwards, 1958) and some crops in Jersey have been severely damaged, both outdoor and under glass (Thomas, 1954–57). The symphylid *Scutigerella immaculata* (Newp.) is mainly responsible and it is often the cause of failure, or considerable loss, in yield of potato crops grown on the south-facing slopes, known locally as "cotils". The crops grown on these slopes are particularly valuable because of their earliness, and failure can cause a loss to the grower of £150 or more per acre.

Irregular patches appear, some three to four weeks after planting (January and February), where growth is arrested and the foliage of the plants is dark green. Such areas remain stunted throughout the growing period and will not respond to fertilizer dressings. Affected plants can be pulled out of the soil with ease because of their skeletal root systems resulting from the destruction of fine roots and root hairs by the symphylids. The animals are readily seen running for cover when such plants are removed, and the small feeding punctures or pitting of both the roots and the young haulm (below ground) of the plants is characteristic.

Good control of symphylids has been obtained in tomato crops under glass with parathion root drenches (Staniland and Stone, 1952), and this treatment has been adopted and used with success for tomato crops under glass and outdoors in Jersey, though annual treatment is necessary. Parathion (5 lb per acre) has also given outstanding control in large plots of cauliflower and cabbage in Washington, U.S.A. (Howitt and Bullock, 1955).

Trials in Jersey, using a drench of parathion on affected potato crops at the time of first appearance of symphylid damage, resulted in good crop recovery and improved yield, but it was evident that treatment at this time was too late. The crop was retarded as a result of earlier damage, and the delay in lifting this early crop to sell on a rapidly falling market resulted in a substantial economic loss.

Using parathion at planting time, so that both the tubers and the soil in the planting furrow were sprayed or watered with parathion solution, was, therefore, tried in 1956 and 1957. Observations of these trials showed that 2·25 lb actual parathion per acre was successful in preventing attack by symphylids but,

because of the high mammalian toxicity of the material and the chances of parathion residues remaining on the tubers, it was decided to examine samples of potatoes from these trials for parathion residues.

TREATMENT

The potato variety, International Kidney, was the same in both years, but planting was earlier in 1956 (February 16 and 17) than in 1957 (April 2). Control was attempted by treatment with parathion at the following rates:

a. 1957 .. .. 8 pints 20 per cent parathion emulsion in 25 gallons of water per vergée (4/9 acre), equivalent to 4·5 lb parathion per acre.

b. 1956 and 1957 4 pints 20 per cent parathion emulsion in 25 gallons of water per vergée, equivalent to 2·25 lb parathion per acre.

c. 1957 .. .. 2 pints 20 per cent parathion emulsion in 25 gallons of water per vergée, equivalent to 1·125 lb parathion per acre.

Treatments a, b and c were sprayed on to the tubers and furrow at the time of planting. In 1957, a further treatment was introduced:

d. 1957 .. .. 2 fluid oz 20 per cent parathion emulsion in 20 gallons of water per Jersey perch (1/90 acre), equivalent to 2·25 lb parathion per acre.

This was watered on the tubers and furrow with a watering can, at the time of planting.

At varying intervals after planting, potatoes were lifted from treated and untreated areas, and random samples taken of both mother tubers (seed potatoes) and new tubers. These samples were placed in numbered polythene bags. The key to the numbers was not given to the analyst until the work was completed, neither was the sequence of numbers kept in any particular form, so as to avoid bias completely. Samples were taken at 5 weeks (1957), 7 weeks (1956), 9 weeks (1956), 10½ weeks (1957) and 12½ weeks (1956).

METHOD OF ANALYSIS

The samples were analysed for parathion, (i) on the surface of the tuber, and (ii) in the whole tuber, by the following procedure which is based on the method of Buckley and Colthurst (1954).

(i) *Surface:* two or three potatoes were washed with 40 ml alcohol (99 per cent). The alcohol washings were filtered into a 150 ml flask and refluxed with 2 ml of 5N sodium hydroxide and 2 ml 100 volume hydrogen peroxide for fifteen minutes. The solution was then cooled, transferred to a 50 ml graduated flask, and made up to the mark with water. The optical density of the solution was measured at 405 mμ, using 1 cm and 4 cm glass cells with the Unicam 0·500 spectrophotometer.

(ii) *Whole potato:* 40 g of sliced potato were weighed into the flask of a homogenizer containing 30 ml of alcohol. After homogenizing, the product was filtered through a No. 4 Whatman filter paper into a 150 ml flask. The extraction was repeated using 25 ml alcohol, and the extract then filtered. The combined filtrates were treated with 2 ml 5N sodium hydroxide + 2 ml 100 volume hydrogen peroxide, and the alcohol distilled off on a steam bath until frothing commenced. The contents of the flask were washed into a 100 ml beaker with water and warmed on the steam bath for thirty minutes, a further amount of hydrogen peroxide being added, drop by drop (to avoid excessive frothing), until no further decolorization took place. After allowing the beaker to stand for four hours (or overnight), the contents were made up to 25 ml with water, and the optical density of the solution measured at 405 mμ.

When a clear solution was not obtained by the above procedure, the solution was acidified and extracted with ether. The ether extract was then shaken with

20 ml of water containing 1 ml of 5N sodium hydroxide and 1 g of sodium chloride. The aqueous layer was made up to 25 ml, and the optical density measured as before. The results, Tables 1 and 2, were read off a calibration curve in the usual way. Recovery checks were also made by adding parathion to untreated potatoes.

TABLE 1

Parathion Content of Mother Tubers in 1956 and 1957

Year	Interval Between Treatment and Sampling *Weeks*	Parathion *lb per acre*	Parathion Residue (p.p.m)	
			On Surface	*Whole Potato (Surface Already Washed)*
1956	7	Nil	<0·01	—
		2·25	2·0, 0·50, 0·60	
1956	9	Nil	<0·30	—
		2·25	0·84, 1·20, 0·50, 1·00	
1957	10½	Nil	0·12	0·30
		1·125	0·17	0·10
		2·25 (b)	2·00	3·30
		2·25 (d)	0·57	0·90
		4·5	2·40, 1·60	1·30, 2·50
1956	12½	Nil	0·03	—
		2·25	0·66, 0·19	

TABLE 2

Parathion Content of New Tubers in 1956 and 1957

Year	Interval Between Treatment and Sampling *Weeks*	Parathion *lb per acre*	Parathion Residue (p.p.m)	
			On Surface	*Whole Potato*
1957	5	Nil	0·09	0·30
		1·125	0·18	0·46
		2·25 (b)	0·16	0·60
		2·25 (d)	0·11	0·80
		4·5	0·30	0·93
1956	9	Nil	—	—
		2·25	0·82	—
1957	10½	Nil	0·04, 0·06	0·49, 0·50
		1·125	0·12	0·79
		2·25 (b)	0·18	0·67
		2·25 (d)	0·10	0·60
		4·5	0·09, 0·08, 0·11	0·42, 1·00, 0·55
1956	12½	Nil	0·13	—
		2·25	0·22, 0·08	—

The parathion residue reported is, in most cases, the result of the analysis of a single random sample. Where replicate random samples were taken and analysed all the figures are given.

SUMMARY

To control symphylids parathion was sprayed on seed potatoes in the furrow at planting time. Samples were taken of the mother and new tubers after various intervals, and these were analysed for parathion. Even with the highest rate of application, the amount of parathion detected on the new tubers did not exceed 1 p.p.m. The highest amounts were detected on the treated mother tubers, as would be expected. Parathion residues could be detected on treated tubers after 12½ weeks.

We wish to thank the Committees of Finance and Agriculture of the States of Jersey for permission to publish these results.

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FUNGICIDAL CONTROL OF POTATO COMMON SCAB

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ALTHOUGH this disease, caused by *Streptomyces scabies* (Thaxt.) Waksm. & Henrici, is not of major importance in the West Midland Region it is frequently of considerable local significance. The effect is mainly on quality rather than quantity in ware samples and, with an increased interest in pre-packing of produce, a disproportionate economic loss is often caused by the reduction in quality which results from a comparatively low incidence of the disease.

In the U.S.A. (Houghland and Cash, 1954; Nugent, 1956), and also in Holland (van Emden and Labruyère, 1958), a considerable measure of control has been obtained with pentachloronitrobenzene (PCNB), which has now been given the common name quintozene.

A replicated trial with a commercial formulation of this fungicide was carried out at Worfield, Bridgnorth, in 1958, and at Lilleshall, Newport in 1959. In both cases a very high degree of tuber infection had previously occurred on the experimental sites. The fungicide was applied by hand to the open drills before planting, at rates equivalent to 0, 25, 50, 100 lb of PCNB per acre, and each

treatment was replicated six times in a randomized block layout. A plot consisted of four drills 20 yards long; the middle two being treated, the outer ones being discarded. Immediately after the fungicide had been placed along the drill the potatoes were machine planted. In 1958, the variety was King Edward; and in 1959, Majestic. The plots were lifted by a two-row digger at the time of commercial lifting; the treated rows in each plot being lifted together, hand picked, bagged, and weighed. Fifty tubers per plot were then selected at random and the amount of disease on each assessed by reference to the standard key diagram (Large and Honey, 1955). The results are summarized in the Table.

The weather conditions in the two growing seasons were entirely different. In 1958, blight, *Phytophthora infestans*, was unusually early and severe, causing premature death of the haulm and an abnormally low yield. The continuous wet conditions which favoured this epidemic were quite unfavourable to the development of common scab, and incidence of the disease was extremely low. In 1959, however, there was a hot dry growing season and infection was high.

Effect of PCNB Treatments on Yield and Incidence of Common Scab

		Treatments: lb PCNB per Acre				Significant Difference ($p = 0{\cdot}05$)
		0	*25*	*50*	*100*	
Mean yield tons/acre	1958 ..	4·7	4·1	4·7	4·3	0·84
	1959 ..	10·6	10·9	11·6	11·4	1·03
Mean percentage of scabbed tubers	1958*	33·6	33·2	27·6	17·6	15·4
	1959**	68·2	71·2	77·6	74·6	15·4

* Up to 1/16 tuber surface affected
** More than 1/8 tuber surface affected

A significant control of common scab was obtained in these trials when the fungicide was applied to the open drills before planting, at a rate equivalent to 100 lb of PCNB per acre—but only in 1958, when the disease incidence was low. No significant control of the disease was obtained in 1959, when its incidence was high.

There was some indication of an increase in yield at the two highest rates of treatment in 1959, but this was not significant at the 5 per cent probability level.

I wish to thank Mr. H. F. Parker at Worfield, Mr. J. V. Dakin at Lilleshall, and my colleagues in the N.A.A.S. for their help with this work.

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PRESERVATION OF SOME PLANT VIRUSES BY FREEZE-DRYING

by M. HOLLINGS* *and* R. A. LELLIOTT

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RAPID vacuum sublimation of water from frozen suspensions (freeze-drying), and subsequent storage under vacuum or nitrogen gas, has been widely and successfully used for the preservation of bacteria, and also for animal viruses and for bacteriophages (Annear, 1957); the subject has been reviewed by Fry (1954) and Harris (1954). It is surprising that there are apparently so few records in the literature of attempts to preserve plant viruses in this way. Dykstra and du Buy (1942) used the technique to preserve potato virus Y and potato Canada streak virus (a strain of potato aucuba mosaic virus), and Finlay and Parker (1954) preserved tomato spotted wilt virus by a method which probably involved evaporative freeze-drying. Best and Gallus (1953) have preserved tomato spotted wilt virus in air at — 20°C in pre-frozen plant tissue dried by rapid vacuum sublimation.

Some plant viruses remain infective for long periods in frozen tissue or sap, or in plant tissue frozen and then dried slowly over calcium chloride (McKinney, 1947, 1953). Tomato aspermy virus in tobacco leaves that we have frozen and dried in this way is still infectious after more than five years, and tobacco necrosis virus after eight years. These methods cannot be used for some labile plant viruses, nor are they satisfactory for preserving many other viruses handled in this laboratory; such preparations lose infectivity too quickly, take up considerable refrigeration space and cannot be sent long distances through the post without being inactivated. This paper gives the results of freeze-drying thirty-nine plant viruses in an attempt to find a method which overcomes these disadvantages.

MATERIALS AND METHODS

Material was freeze-dried by the centrifugal vacuum freezing method of Greaves (1944) in a slightly-modified Edwards Model L.5 freeze-drier, using phosphorus pentoxide as a desiccant. Vacua were measured with a Pirani gauge. Infected plants were harvested when experience from previous infectivity tests indicated that the concentration of virus had reached its maximum. Aliquots, usually 0·25 ml, of expressed sap to which had been added 7 per cent w/v peptone (Oxoid) and 7 per cent w/v d-glucose, were placed in 0·5 ml capacity ampoules (Edwards), and stored overnight at 0°C. The ampoules were centrifuged during the first five minutes of pumping, and dried for 6–24 hrs. Full air ballast was used initially (usually for 5–10 minutes) until the pressure had fallen to 0·05 mm Hg. Pressure was 0·02 mm Hg after about 15 minutes and a final pressure of 0·007–0·014 mm Hg was reached with most batches within three hours. After this primary drying, ampoules were constricted, dried on "sows" for a further 16–24 hours (6–8 hours only for a few cultures) at 0·009–0·02 mm Hg, and sealed off at this pressure. The sealed ampoules were stored at room temperature. This method of freeze-drying was chosen arbitrarily because, in this laboratory, it had been found to give good results with bacteria.

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TABLE 1

Reactions of the Viruses to Freeze Drying

Virus	Source Plant	Indicator Plant	Infectivity		
			After 24 Hours	*After n Months*	n
Anemone mosaic	11	3	***	*	5
Anemone necrosis[1]	12	16	***	***	7½
		13	***	***	7½
Beet mosaic	11	3	*	*	7
Beet ringspot	13	13	***	***	4
		7		***	4
Broad bean mottle	11	11	inf.	inf.	11
		17	inf.	inf.	11
Cabbage black ringspot	12	3	*	*	5
Carnation mottle	6	3	***	***	5
Carnation ringspot	6	3	***	***	5
Carnation vein mottle	6	3	*	**	6
Cauliflower mosaic	2	2	inf.	inf.	9½
Celery yellow net[2]	1	1	inf.	inf.	5
Celery yellow vein[2]	13	13	***	***	5
Chrysanthemum vein mottle	11	11	inf.	inf.	3
Cucumber green mottle	4	4	inf.	inf.	5
Cucumber mosaic (7 strains)	13	3	** – ***	* – ***	4–6
		13	** – ***	** – ***	4–6
Cucumber stunt mottle[3]	11	13	***	***	5
		7	***	***	5
Cymbidium mosaic	5	3	*	*	4
Henbane mosaic	13	3	**	**	5
Hydrangea ringspot	8	3	**	**	5
		7		**	5
Lettuce mosaic	9	3	*	*	4½
		11	inf.	inf.	4½
Lucerne mosaic	13	13	***	***	9
		14	***	***	9
Narcissus virus	10	7	**	*	7
		16	**	**	7
Pea mosaic virus	11	11	inf.	inf.	10½
Pelargonium leaf curl (2 strains)	11	3	***	***	6
		16	***	***	6
Potato paracrinkle	11	11	inf.	inf.	8
Potato virus A	12	11	not inf.	not inf.	
		12	not inf.	not inf.	
Potato virus C	12	13	*	*	7
		15	**	*	7
Potato virus G	12	12	***	**	5
Potato virus X	13	13	***	***	5
		7	**	***	5
Raspberry ringspot	11	3	***	**	4
Raspberry yellow dwarf	13	16	***	**	9
	12	3	***	**	9
Tobacco necrosis	13	13	***	***	5½
		14	***	***	5½
Tobacco rattle	13	13	***	**	5½
		16	***	***	5½
Tobacco ringspot	13	13	***	***	4
Tobacco severe etch	12	13	***	**	7
Tomato aspermy	13	3	***	**	4
Tomato black ring	13	13	***	**	5
Tomato bushy stunt	11	12	***	***	4
Tomato spotted wilt	12	12	**	*	4

[1]. Anemone necrosis is an undescribed virus isolated from roots of *Anemone coronaria* L.

[2]. Celery yellow net and celery yellow vein are two viruses isolated from *Apium graveolens* L.

[3]. Cucumber stunt mottle is an unrecorded virus from *Cucumis sativus*.

Infectivity was determined by reconstituting the contents of an ampoule in 1·5 ml of M/15 phosphate buffer (pH 7·0) and inoculating appropriate indicator plants with the suspension, to which a little Celite powder had been added.

RESULTS

Table 1 lists the viruses tested, and the plant species used to culture the virus and as an indicator of infectivity in each case. No quantitative comparison was made to show the proportions of infectivity lost during drying and storage, but local lesion host plants were used where possible, and the numbers of lesions produced were assumed to give a good indication of the infectivity of the preparation. In the Table *** indicates high infectivity, i.e., the number of lesions was of the same order as normally obtained by inoculation with fresh sap; ** indicates moderate infectivity or considerably fewer lesions, and * low infectivity or very few lesions compared with fresh sap. In the absence of a local lesion host, preparations of a few viruses could only be designated infective (inf). The plants used (with their reference numbers in Table 1) were:

1. *Apium graveolens* L. var *dulce* Pers. (Golden Marvel Blanching)
2. *Brassica pekinensis* Rupr.
3. *Chenopodium amaranticolor* Coste & Reyn.
4. *Cucumis sativus* L. (Butcher's Disease Resister)
5. *Cymbidium* sp.
6. *Dianthus barbatus* L.
7. *Gomphrena globosa* L.
8. *Hydrangea macrophylla* Ser.
9. *Lactuca sativa* L. (Cheshunt Early Giant)
10. *Narcissus* sp. (flowers)
11. *Nicotiana clevelandii* Gray
12. *Nicotiana glutinosa* L.
13. *Nicotiana tabacum* L. (White Burley)
14. *Phaseolus vulgaris* L. (Prince)
15. *Physalis floridana* Rydb.
16. *Tetragonia expansa* Murr.
17. *Vicia faba* L. (Aquadulce)

The plant names are taken from Bailey (1954).

DISCUSSION

Of the forty-six isolates of thirty-nine viruses tested only one, potato virus A, was not infective when freeze-dried in this way. No accurate quantitative data were obtained on the survival of infectivity for each virus, but it appears from a comparison of infectivity 4–11 months after freeze-drying with the infectivity expected of fresh sap, that those viruses with spherical particles lost little or no infectivity, whereas several of the viruses with rod-shaped particles (including beet mosaic, cabbage black ringspot, cymbidium mosaic, henbane mosaic and hydrangea ringspot) had lost much of their infectivity.

Cowan (1951) reported cross-contamination between ampoules in the drying chamber of a centrifugal freeze-drier when a number of different bacterial cultures were freeze-dried together. Apparently this resulted from the discharge of particles of material from ampoules during the initial drying process. Although the viruses in our trials were dried in groups of three, no instance of cross-contamination has been observed.

The method appears to be promising and, if developed successfully, would be of particular value to culture collections which regularly distribute plant viruses, and in experiments requiring preparations of virus of approximately equal infectivity over a period of time. Work is continuing to estimate more accurately the survivals of preserved viruses and to determine the conditions of drying giving the highest survival rates.

SUMMARY

The preservation of sap preparations of forty-six isolates of thirty-nine plant viruses by rapid sublimation of water from frozen suspensions and subsequent storage under vacuum (freeze-drying) was studied. Infective virus was recovered

from preparations of all strains, except one of potato virus A, after freeze-drying and after storage from periods varying from four to eleven months. It appeared that the spherically shaped viruses studied lost little or no infectivity during freeze-drying, but that several of the rod-shaped viruses lost much of their infectivity. There was no evidence of further serious loss of infectivity in forty-five of the preparations during the storage period.

We should like to thank Mrs. F. E. Smith and Miss D. M. Stacy, for valuable technical assistance.

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COUNTING POTATO ROOT EELWORM CYSTS AFTER METHAM-SODIUM SOIL TREATMENT

by D. W. EMPSON

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TOWARDS the end of October 1959, a sample of soil was received from a glasshouse in Warwickshire. It had been treated by watering with a proprietary formulation of sodium methyldithiocarbamate (metham-sodium) in January 1959, and had grown a successful crop of tomatoes during the year. Cysts of potato root eelworm, *Heterodera rostochiensis* Woll., were extracted, by flotation in water, from 50 g of air-dried soil. The sample yielded 174 cysts of which 160 appeared to be viable. It was noticed, however, that these apparently viable cysts, when roughly opened with needles, never released free larvae. Healthy cysts from untreated soils almost invariably produce a number of free larvae, presumably because of the ease with which the eggs burst open under pressure. Further examination showed that larvae extracted from eggs from the treated cysts remained in one or other of the bent positions described by Staniland and Stone (1953). No normal cysts were found in this soil.

A sample from a glasshouse at another Warwickshire nursery, which had also been treated with metham-sodium, yielded 135 apparently viable cysts. Thirty of these gave normal, straight larvae, but 105 produced no larvae when roughly opened and larvae extracted from eggs remained bent and kinked.

A second sample of soil was taken from the original site on December 10. Similar results were obtained, but on this occasion it was thought that, although from the outside the cysts appeared fresh and healthy, there was some slight discoloration of the eggs. The larvae appeared faintly granular and their outline within the egg was more marked than usual.

A final sample was taken on January 12, 1960. The cysts still looked healthy, but the eggs were obviously becoming discoloured and larvae could be extracted from them only with difficulty. There was, in fact, little doubt that they were dead.

It was, therefore, exactly a year after treatment that it became possible to be reasonably certain, from quick visual examination alone, that the cysts had been killed; even then unopened cysts appeared to be healthy. The time from treatment to visible break-down of the eggs may of course vary with soil conditions, but in this case it was eleven months before the first signs were detected.

Difficulty is likely to be experienced in judging the degree of control achieved by metham-sodium until at least a year after treatment. Hatching tests are slow and according to Fenwick (1959) are only applicable to normal cysts, i.e., those that have not been treated with nematicides. Possible staining methods for separating live and dead eggs have not been considered as they would be too time-consuming for routine work.

The positions assumed by the larvae after extraction from the eggs give the best guide but, according to Staniland (1959), several weeks must elapse between treatment with the nematicide and examination of the cysts. Even this method takes more time than can be spared in routine work, since the cysts should be soaked for at least seventy-two hours before opening (Staniland, 1959).

A possible compromise may be reached by extracting the cysts in the normal way and opening them very roughly with a pair of blunt needles. Those that produce free, straight larvae are considered viable; those that produce only apparently normal eggs, with or without bent larvae, are classed as doubtful, and the obviously empty or discoloured ones as dead. Where the proportion of doubtful cysts is high a more detailed examination is made, or a second sample is taken at least a year after treatment. Soils known to have been treated should not be sampled until at least two months after the treatment was given.

It may be noted that the same difficulty occurs with samples taken shortly after steam sterilization. Cysts examined fifteen days after this treatment gave larvae which remained bent and kinked, although neither the cyst walls nor the eggs were noticeably discoloured.

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FURTHER EXPERIMENTS ON THE CONTROL OF BULB FLY IN NARCISSUS

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THE use of 0·2 per cent aldrin cold dip to control *Merodon equestris* (Feb.) (Woodville, 1955, 1957) has continued to be successful in practice. This has been confirmed by further experiments at Ellbridge Experimental Station, and by observations on commercial holdings. Further experiments have been carried out to find other methods of control and also to check that the strength of cold dip, i.e., 0·2 per cent, is the best. Previous work (Woodville, 1955) showed that no advantage was obtained by using the chemical at 0·4 per cent, so experiments were laid down using strengths of 0·05 per cent, and 0·1 per cent aldrin, compared with the standard 0·2 per cent. Flower picks showed little difference between plots, except that they were lowest on the untreated two-year-down beds.

TABLE 1

Effect of Treatment on Percentage of Bulbs Attacked by Bulb Fly (Variety, King Alfred, Bulbs Hot Water Treated, Dipped for 15 Minutes, Planted in 1957 and 1958, Examined in 1959)

Treatments *per cent*	Bulbs Down One Year (Mean of Two Replicates)	Bulbs Down Two Years (Mean of Three Replicates)
Aldrin .. 0·05	41	12
Aldrin .. 0·1	58	6
Aldrin .. 0·2	6	3
Control .. —	70	19

In spite of the variation between results it seems clear (Table 1) that a strength below 0·2 per cent (actual chemical) does not give satisfactory control of damage. Therefore, for all advisory work it has been decided to retain the recommendation of a dip of fifteen minutes in 0·2 per cent aldrin.

As mentioned above, this method has given excellent control of damage in commercial practice, but, in one case, quite serious damage was seen and very poor growth followed this treatment. A considerable acreage of bulbs was involved, and careful investigations were made. Fortunately the grower concerned kept very careful records, and it was found that the later in the season the hot water treatment had been carried out the more serious was the check to growth. It seemed quite certain that some root development must have started, and that the hot water treatment itself had done some damage; the treatment with aldrin or dieldrin making the damage worse. By careful comparison of stocks which had been treated at the correct time with those which had been treated later, it was seen that the check to growth was small or negligible when treatment was done at the correct time, but that it increased to a very serious check when they were treated very late. The actual enumeration of late or very late is difficult but, as a rough guide, it was decided that once the root initials had started to swell there would be a risk of appreciable damage if the aldrin dip followed hot water treatment.

Work in the United States (Doucette, 1959) and in Canada (Andison, 1954, 1957; Andison and Cram, 1959) had shown that the application of insecticides to the soil immediately below the bulb had been successful in stopping attack by the bulb fly. Because of the damage caused by treating too late in the season, these methods were tried out in Cornwall. Work was started in 1957, but the summer of 1958 was so bad that the bulb fly attack was light and patchy, and some results on bulbs lifted in July 1958, were inconclusive.

Two materials were selected: 1¼ per cent aldrin dust and 40 per cent chlordane emulsion. The chlordane was applied at 10 lb actual per acre and the aldrin at about 7 lb actual per acre. In practice the drills for the bulbs were taken out, and either aldrin dust at 4½ lb per 100 yards of drill (drills 10 inches apart) was applied in the bottom of the drill, or one fl. oz of 40 per cent chlordane per 44 yards of drill was applied in a convenient amount of water. The bulbs, previously hot water treated were then placed on top of the insecticide and the drill closed. The results are shown in Table 2. No phytotoxic damage was seen during the growing season. Flower picks showed little variation between treatments.

TABLE 2

Effect of Treatment on Control of Bulb Fly
(Varieties, King Alfred (two years down) and Carlton (one year down), Hot Water Treated in 1957 or 1958 and Lifted and Assessed in 1959)

Treatment	Bulbs Down One Year (Total of Two Replicates)			Bulbs Down Two Years (Total of Three Replicates)		
	No. of Damaged Bulbs	*No. of Clean Bulbs*	*Per Cent Damage*	*No. of Damaged Bulbs*	*No. of Clean Bulbs*	*Per Cent Damage*
Aldrin dust ..	3	291	1	1	357	0·3
Chlordane spray ..	10	277	3·5	3	370	0·8
Control	145	62	70·0	60	279	17·7

While this later work was in progress growers were already asking for an alternative to the aldrin dip. Some, with insecticidal resistance in mind, felt an alternative method was needed, although no signs of the resistance of *Merodon* to insecticides had been detected. Others felt that, following the damage already mentioned, the method, while good, was not foolproof. Another adverse comment was that a large amount of labour was required for the dipping. On some holdings the standard practice is to spread fertilizer along the bottom of the drill just prior to placing the bulbs, and closing the drill. If an insecticide could be incorporated in the fertilizer, it was felt that this would be a good method, as no extra labour was involved. While the experiments described were in progress one large grower had actually carried out this method. The fertilizer used was one compounded to his own specifications, to which was added aldrin to give approximately 7 lb actual aldrin per acre. While detailed counts were not made, his report was that control of bulb fly damage had been excellent. In another case the method seemed useful when hot water treatment had been delayed and it was felt that it would be unwise to dip the bulbs in aldrin.

SUMMARY

The strength of 0·2 per cent for aldrin in the cold dip appears to be the best, a lower percentage allows more bulb fly damage, a higher percentage gives no

extra protection. The use of aldrin dust or chlordane spray applied to the bottom of the drill just prior to planting bulbs gives good protection against bulb fly attack. Amounts used were 10 lb of actual chlordane per acre, or 7 lb actual aldrin per acre. This can be incorporated in the fertilizer.

Thanks are due to various members of the Entomology Department at Starcross; and to the staff of the Ellbridge Experimental Station for help in this work.

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FURTHER OBSERVATIONS ON FRIT FLY CONTROL IN SOUTH WALES

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WORK on the use of dieldrin for the control of frit fly in spring oats in South Wales has been summarized by Fidler (1958). It was suggested, from the evidence of field trials, that the insecticide applied for controlling first generation attack also gave some control of the later panicle attack. In 1959, an attempt was made to investigate this effect. Three half-field trials were carried out. The average size of each was five acres, half of which was sprayed with dieldrin at the rate of one-third gallon of a 15 per cent miscible formulation plus 8 oz of Manoxol O.T. per acre in 40 gallons of water. In each case the sprayed and unsprayed areas were rectangular in shape. Details of the trials were as follows:

Site:	*Highmead, Monmouth*	*Henstaff, Glamorgan*	*Dan-y-Parc, Brecon*
Planting date	April 23	April 14	April 30
Spraying date	May 29	June 15	May 27
No. of leaves at spraying	4·1	5·5	3·2
First generation sample date	June 10	June 21	June 10
No. of leaves at sampling	5·5	7·0	5·8
Sampling panicles for eggs at anthesis ..	July 7	July 6	July 8
Harvesting date	August 17	August 10	August 13

Control of the first generation varied; at Highmead the attack was reduced from 27 to 11 per cent, based on two samples each of twenty-five plants dissected in the laboratory. Henstaff and Dan-y-Parc had low attacks, 10 per cent in the former and 7·3 per cent in the latter, both sprayed and unsprayed giving a similar figure.

At anthesis, ten samples, each of ten panicles per plot, were taken, and the frit fly eggs and thysanoptera present were extracted (Webley, 1957). No attempt was made to differentiate between the species of thrips. At harvest time, ten grab samples of grain were taken from each plot, and the degree of frit fly infestation recorded. An analysis of variance was carried out on the data, the egg and thrip figures being transformed to $\sqrt{n + 0{\cdot}5}$, and the grain figures subjected to an angular transformation. The mean plot results were:

		Egg Density	Thrip Density	Grain Damage
Highmead	Sprayed	3·5	8·2	17·1
	Unsprayed ..	6·4	16·3	27·3
Henstaff	Sprayed	1·8	3·3	11·4
	Unsprayed ..	2·3	4·0	11·1
Dan-y-Parc	Sprayed	3·5	8·6	11·9
	Unsprayed ..	5·4	10·3	18·0
S.E. per plot		0·9	1·96	1·97
Significant difference (p = 0·001)..		0·81	1·77	1·78

There was a highly significant decrease in the number of eggs laid on the sprayed plots at Highmead and Dan-y-Parc, where the sprays had been put on at the peak of first generation adult activity. At Henstaff, which had been sprayed when the peak was well passed, there was no significant difference. The thrip figures at Highmead gave the same results, the sprayed plot having fewer thrips than the unsprayed one; there was also a similar tendency at Dan-y-Parc. As might be expected, the degree of grain attack by frit fly followed the same pattern as the panicle egg counts.

The results confirm previous observations in South Wales (Fidler, 1958). A dieldrin spray applied at peak adult first generation emergence, gives some control of tiller attack, and reduces the panicle infestation. (This differs from Jepson's (1959) findings that when parathion or endrin sprays are applied to control the first generation, no control of the second generation is achieved.) The present figures seem to suggest, at least for the South Wales area, that a spray of dieldrin does alter the field population. This is not necessarily due to direct control of the pest in the plant, since at Dan-y-Parc no difference could be detected between the sprayed and unsprayed plots on June 10. It is assumed that the insecticide has altered the adult population on the sprayed plants, without altering the degree of attack on the young plants.

The thrip populations tend to move in step with those of frit fly infestations at all sites (Table 1). This is not surprising, as the work of Lewis (1959), has shown that *Limothrips cerealium* Hal. lays eggs on corn in late May. At Highmead and Dan-y-Parc the dieldrin spray was applied in time to affect the build-up of both frit and thrip populations; at Henstaff the spray was applied too late for this to be achieved.

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TWO MICROPLOT TRIALS WITH THIMET AGAINST PEA ROOT EELWORM

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IN a simple test, in 1956, to find whether the systemic insecticide Thimet (O, O, diethyl S–(ethylthiomethyl) phosphonodithioate) destroyed pea root eelworm, *Heterodera göttingiana* Liebscher, pea seed was dressed at the rate of 9 oz of the active substance per bushel, and sown in pots of eelworm-infested soil, together with non-dressed seed. Root examination at the flowering stage showed that far fewer cysts had developed on the Thimet treated peas. In 1957 and 1958, microplot trials were carried out. The microplots were constructed of rebated wooden planking, and were two-feet square and held four cubic feet of top soil.

1957 EXPERIMENT

To obtain different pea root eelworm population levels, cysts were mixed with "eelworm free" soil. The cysts were obtained from a field near Holbeach, Lincolnshire, by washing a large quantity of soil through an 80 mesh sieve. The float contained much organic matter, and the cysts were separated by re-floating twice with water and by passing over a vibrator (Cooper, 1955).

Nemagon (1, 2–dibromo–3–chloropropane) was included in the trial in 1957. There were two plots for each of the following combinations, the amounts of insecticides stated being amounts of *active substance* in each case:

In soil with initial eelworm population nil

1. Peas. Untreated control.
2. Peas. Thimet applied as in combine drilling at 5 lb per acre.

In soil with initial eelworm population low (average 0·11 eggs per g)

3. Peas. Untreated control.
4. Peas. Thimet applied as in combine drilling at 5 lb per acre.

In soil with initial eelworm population high (average 0·59 eggs per g)

5. No crop. Untreated control.
6. Peas. Untreated control.
7. Peas. Thimet applied as in combine drilling at 5 lb per acre.
8. Peas. Thimet applied as in combine drilling at 30 lb per acre.
9. Peas. Nemagon mixed in top 8 inches of soil at the rate of 30 lb per acre.
10. Vetches. Thimet mixed in top 4 inches of soil at the rate of 10 lb per acre.

Because Thimet caused some death of seedlings when used as a seed dressing (Anon. 1957), the chemical was applied to the microplots as if combine-drilled, i.e., placed in the drills around and just beneath the seed. Chemical treatments and sowings were made on April 16, with the exception of the Nemagon plots which were sown on May 11. A short-strawed pea, Rondo, was sown in eight-inch rows, three rows per plot. The vetches were sown broadcast and were cut early (June 17), soon after the first flowers appeared. All remaining vetch growth was burnt off with a high dose of dinoseb on July 3.

There were no visual differences between treatments and no marked differences in straw length. When the eelworm population was low or nil, the yield was greater where Thimet was applied. At the high population level, yield was greatest where Thimet was applied at 30 lb per acre and lowest at 5 lb per acre.

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Thimet at 30 lb per acre reduced cyst numbers on the upper roots, but the lower ones were badly infested. The cyst-free areas were noticeably less decayed than the lower, infested areas. Roots on the Nemagon treated plots had a cyst infestation similar in numbers to those on both low infestation treatments, but the cysts themselves were smaller.

Eelworm population changes are shown in Fig. 1. The lowest final populations followed Nemagon and vetches.

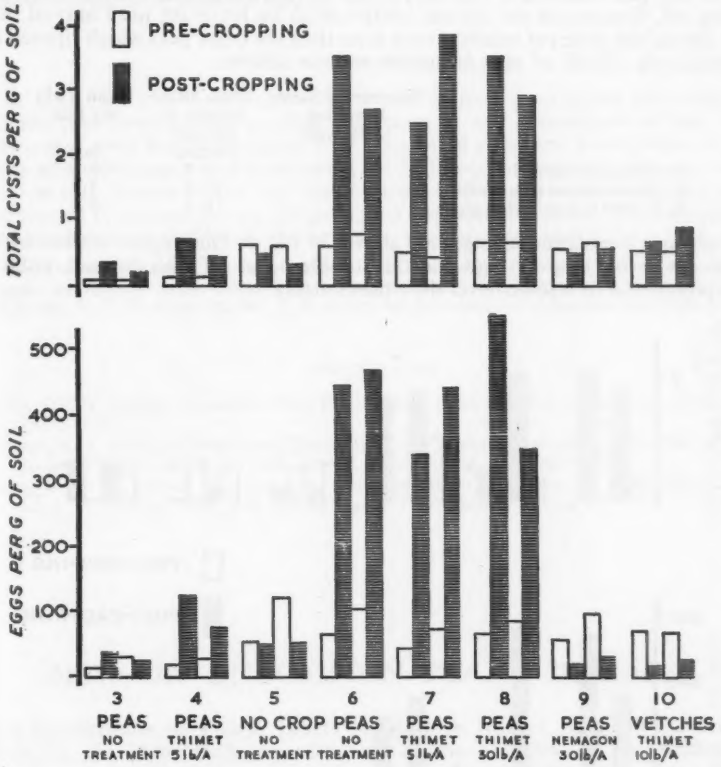

Fig. 1. Eelworm population changes in 1957 experiment.

1958 Experiment

It seemed possible that Thimet might move upwards through the root system, and so prove effective if placed in a band well below the seed. Alternatively, mixture with the top soil might be the more effective method if translocation within the roots were limited. A vetches-without-Thimet treatment was included to separate the effect of early cutting and Thimet, which together gave low populations in 1957. Thus the combinations tested in 1958 were:

1. Peas. Untreated control.
2. Peas. Thimet mixed in top 6 inches of soil.
3. Peas. Thimet placed in band 7 inches below seeds.
4. Vetches. Untreated control.
5. Vetches. Thimet mixed in top 6 inches of soil.
6. No crop. Untreated control.

Soil naturally infested with eelworm was used for the experiment in 1958, the source being the same as in 1957. Thimet was used at the rate of 10 lb active substance per acre, and sowing took place on April 23, immediately after application of the chemicals. The same pea variety and row spacing was used as in 1957, and treatments were again duplicated.

By early June, the peas with Thimet mixed-in contrasted strikingly with the other two pea treatments, where all plants were stunted and yellow, or actually dying off. Growth on the former continued to be luxuriant until harvest, and the plants had to be cut nearly a week later than the other peas which ripened off prematurely. Yields of peas at harvest were as follows:

	Number of Stems Surviving to Harvest	Mean Straw Length at Harvest (*inches*)	Mean Yield per Plot (*oz*)
1. Untreated control	39	9·3	0·6
2. Thimet mixed in top soil ..	79	17·1	3·7
3. Thimet in band below seeds ..	44	10·4	0·8

Eelworm population changes are shown in Fig. 2. Once again vetches which were cut early (June 19) and had the stubble burnt off with dinoseb, reduced the population to a lower level than the controls.

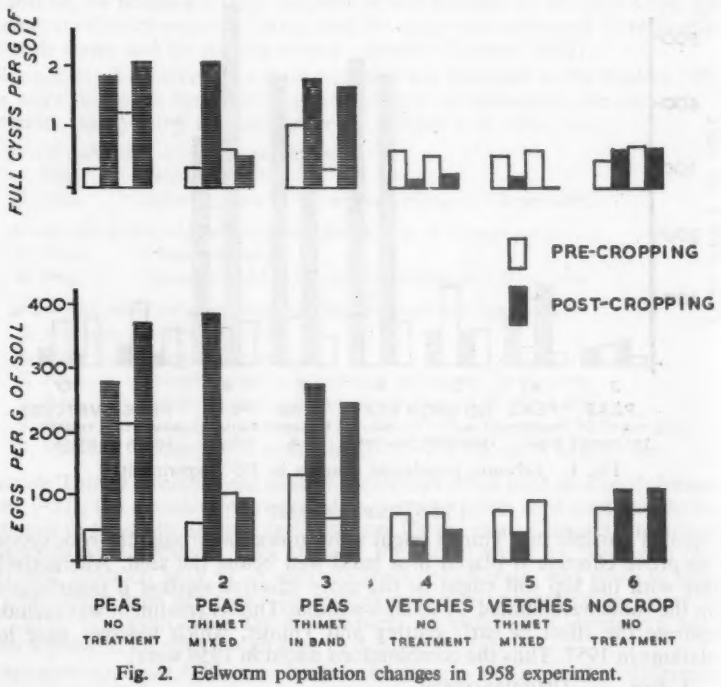

Fig. 2. Eelworm population changes in 1958 experiment.

DISCUSSION

Thimet was most effective when mixed thoroughly in the top soil, enabling good crop growth to be made, but permitting multiplication of the eelworm.

Because of the latter and of the high cost of the treatment, Thimet cannot be regarded as satisfactory for commercial use for this purpose.

Population levels which caused failure in 1958 were lower than those which had no apparent effect in 1957. This might have been due to the harmful effect of drying on the cysts during extraction in 1957, or possibly to the elimination of some other pathogen present in the Holbeach soil, or perhaps solely to different seasonal effects. A similar failure to obtain collapse symptoms with higher populations is mentioned by Jones (1959).

SUMMARY

In microplot trials, early-cut vetches with Thimet (two years) and without Thimet (one year) caused marked reductions in soil populations of pea root eelworm. Lower final populations were also found after peas were grown on the plots where Nemagon had been mixed (at 30 lb active substance per acre) with the top soil. Thimet mixed into the top soil at 10 lb active substance per acre suppressed symptoms in peas but permitted population increase. Thimet applied in a band with or well below the seed row, was relatively ineffective.

Thanks are due to Mr. C. T. Guile and Miss E. C. Mason for making the cyst and egg counts. Thanks are also due to the farmer from whose land the cysts and infested soil were obtained, and to Mr. F. G. W. Jones and Mr. E. B. Brown for assistance in the preparation of this paper.

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NEW OR UNCOMMON PLANT DISEASES

Bud Proliferation on Potato Tubers in Northern Ireland. Since 1948 we have dealt, in the Plant Pathology Division of the Ministry of Agriculture for Northern Ireland, with twenty-four cases of bud proliferation in potato tubers, as described by Pethybridge, Moore and Smith (*Bull. Minist. Agric., Lond.*, No. 79, 1934, 36–7). In twelve of these cases (five in Up to Date, two in Stormont Dawn, and one each in British Queen, Kerr's Pink, Dunbar Standard, Golden Wonder and Ulster Malta) the abnormality was found to be present at or soon after lifting. These were all in the years 1949, 1955 and 1959, when the summers were warm and dry, favouring the development of common scab, *Streptomyces scabies* (Thaxt.) Waksman and Henrici. It was noteworthy that in all these crops in which bud proliferation was noted at lifting, common scab was also present and often severe (Plate III, 1. Photograph by Mr. Robert McIlwaine). In one of these crops (Stormont Dawn, 1955) at least 20 per cent of the tubers showed bud proliferation at lifting, and this was thought to be related to poor cultivation and a check to growth as well as to seasonal conditions (*Res. Exp. Rec. Minist. Agric. N. Ire.* 1957, **5**, 133–4). In the other twelve cases (four in Arran Pilot, two in Majestic, one each in Stormont Dawn, Arran Peak and

Home Guard, and three in other varieties), the bud proliferation was noted in late winter or spring, after storage, and there was no consistent association between the bud proliferation and common scab or any other disease of the tubers.

E. L. CALVERT and A. E. MUSKETT

Rhododendron Leaf Spot in Britain. Rhododendron foliage with leaf spot, a disease caused by *Cercospora handelii* Bubak (syn. *C. rhododendri* Marchal & Verpl.) was received at Wye from a Surrey nursery in July 1959. The disease was largely restricted to about one-eighth of an acre of two-year-old plants up to about 2 feet high, the majority of which were affected to some extent. Symptoms were usually confined to the lower foliage (much of which had been removed as a control measure), but some plants had only a few apical leaves remaining free from spotting. Several varieties were attacked—Doncaster, Blue Peter and Purple Splendour apparently more severely than the others. The spots were dark brown on the upper leaf surface, with purplish margins in some varieties, but paler below. They were often rather angular, being delineated by the veins; but they tended to become more circular later (Plate II, 1), with a diameter of 1 cm or more, although sometimes coalescing along the leaf edges. Under moist conditions simple conidiophores bearing conidia were copiously produced on both sides of the spot, appearing to the naked eye as a brownish green powder. The subhyaline multiseptate conidia (Plate II, 2) measured 20–100 × 1·5–3 μ, falling within the range given for this species by Chupp (*A Monograph of the Fungus Genus* Cercospora, Ithaca, New York, 1953), with whose description there was equally good agreement in other respects.

The disease has been reported from Australia, Belgium, Czechoslovakia, Holland, Israel, Japan, New Zealand, U.S.A. and U.S.S.R. on *Rhododendron* spp. On the Surrey nursery occasional leaf spots were seen during the previous three years, but there was nothing comparable with the extensive spotting which developed in 1959. It is likely, however, that the fungus has a longer history in Britain: a *Cercospora* species on rhododendron was recorded from Hampshire in 1951 (Moore, W. C. (1959). *British Parasitic Fungi*, Cambridge University Press, p. 93), and the spore measurements of this fungus have been found to fit those of *C. handelii*. Affected foliage was removed and burnt on the Surrey nursery during July and August 1959, and there has been no recurrence. Azaleas on the nursery were not affected.

W. T. DALE

Violet Root Rot on Alstroemeria. Roots of *Alstræmeria aurantiaca* Don. in various stages of decay, and showing the violet coloration and mycelial strands typical of violet root rot, *Helicobasidium purpureum* Pat., (Plate III, 2), were received from a grower in Holland, Lincolnshire. The roots had been planted five years previously and were disease free until the summer of 1959, when plants at one end of the bed began to die off just as the flowers began to open. The bed of *Alstræmeria* and the adjoining land had not carried a crop susceptible to violet root rot since it was under potatoes ten years ago. Nearby beds of *Alstræmeria ligtu* hybrids, scabious and *Chrysanthemum maximum* were unaffected. *Alstræmeria aurantiaca* does not appear to have been previously listed as a host for this fungus.

J. T. FLETCHER and J. H. HAWKINS

(79612) Wt. 27 K.9 6/60 Hw.